AD-A161 638 ANNUAL GASEOUS ELECTRONICS CONFERENCE (38TH) HELD AT MONTEREY CALIFORNIA ON 15-18 OCTOBER 1985 PROGRAM AND ABSTRACTS(U) NAVAL RESEARCH LAB WASHINGTON DC 1/2

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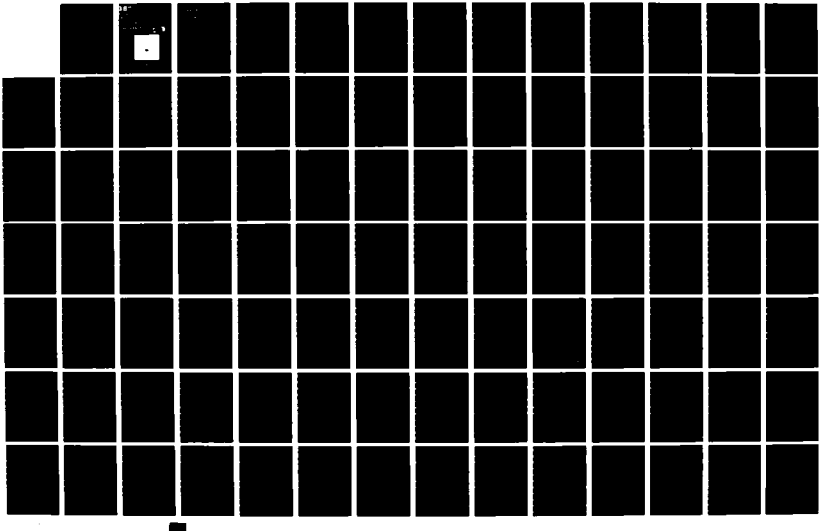

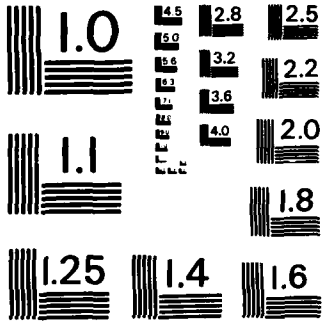

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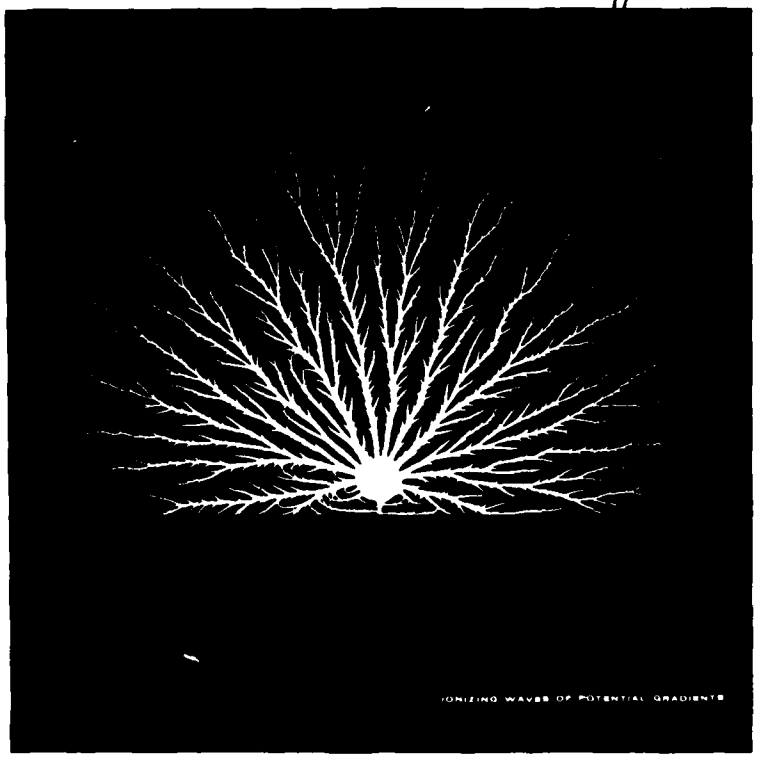
38th annual GASEOUS ELECTRONICS CONFERENCE



15-18 October 1985

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

Thirty-eighth Annual

Gaseous Electronics Conference

October 15-18

Program and Abstracts

A Topical Conference of the American Physical Society

Hosted by:

Department of the Navy
Naval Postgraduate School

Assisted By:

Office of Naval Research
Air Force Office of Scientific Research
National Science Foundation

ACKNOWLEDGEMENTS

On behalf of the Membership, the GEC Executive Committee gratefully acknowledges the support of the host institution. The Naval Postgraduate School provided staff and facilities without which the Conference could not be held. Financial assistance has been provided by the Office of Naval Research, the Air Force Office of Scientific Research, and the National Science Foundation. The Gaseous Electronics Conference is a Topical Conference of the American Physical Society with sponsorship by the Division of Electron and Atomic Physics.

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TUESDAY AFTERNOON, 15 OCTOBER

C: POSTERS

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CA- 2 ELECTRON DRIFT VELOCITY AND ATTACHMENT AND IONIZATION COEFFICIENTS IN C_2F_6/Ar AND C_2F_6/CH_4 GAS MIXTURES AT ELEVATED GAS TEMPERATURES. J.G. Carter, S.R. Hunter, and L.G. Christophorou, Oak Ridge Nat'l Lab

CA- 3 RECOMBINATION OF Ar_2^+ IONS WITH ELECTRONS IN ATMOSPHERIC-PRESSURE AMBIENT HELIUM. R. Johnsen and H.S. Lee, U. of Pittsburgh

CA- 4 ELECTRON-ION RECOMBINATION RATES IN AN ATMOSPHERIC PRESSURE PLASMA. S.M. Jaffe, M. Mitchner, S.A. Self, Stanford U.

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CA- 6 EXCITATION OF NEON $2p^5 3p$ LEVELS BY LOW ENERGY ELECTRON BEAMS. M.B. Schulman, F.A. Sharpton, L.W. Anderson, and C.C. Lin, U. of Wisconsin-Madison

CA- 7 ENERGY LOSS SPECTROSCOPY OF XENON DIFLUORIDE. M. Dillon, H. Tanaka, and D. Spence, Argonne Nat'l Lab

CA- 8 MEASUREMENTS OF THE ABSOLUTE CROSS SECTIONS FOR IONIZATION AND FRAGMENTATION OF SiF_3,SiF_2,SiF, and Si BY ELECTRON IMPACT. T.R. Hayes, R.C. Wetzel, and R.S. Freund, AT&T Bell Labs

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CA-11 ELECTRON EXCITATION PROCESSES IN HYDROGEN NEGATIVE ION DISCHARGES. J.R. Hiskes, A.M. Karo, and T. De Boni, Lawrence Livermore Nat'l Lab

CA-12 AUTODETACHED ELECTRON ENERGY SPECTRUM FROM METASTABLE He_2^-. Y.K. Bae and J.R. Peterson, SRI Internat'l

CA-13 POSITRON-SiH_4 SCATTERING (0.1-6 eV). A. Jain, JILA, U. of Colorado and NBS, and D.G. Thompson, Queen's U., Belfast

CA-14 REACTIONS OF He_2^+ AND $He(2^3S)$ WITH N_2,O_2, AND CO_2 AT ATMOSPHERIC PRESSURES. J.M. Pouvesle and J. Stevefelt, GREMI, U. of Orléans and H. Jahani, V.T. Gylys, and C.B. Collins, U. of Texas-Dallas

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CA-20 MEASUREMENT OF SF_6 IONS WITH GERDIEN COUNTER. J.P. Novak and G. Ellena, IREQ, Varennes, Québec

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CB- 2 DECOMPOSITION RATES OF SF_6 IN SF_6/Ne AND SF_6/N_2 CORONA DISCHARGES. M.C. Siddagangappa, R.J. Van Brunt, and A.V. Phelps, Nat'l Bureau of Standards

CB- 3 THE RECOVERY OF A HIGH PRESSURE DIFFUSE DISCHARGE. R. Piejak, GTE Labs Inc.

CB- 4 EXPERIMENTAL STUDY OF LASER TRIGGERED ELECTRICAL BREAKDOWN IN AIR. S. Yoshida, S. Kubodera, R. Ozaki, T. Sakai, and T. Uchiyama, Keio U., Yokohama

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CB- 6 IONIZATION EQUILIBRIUM IN A DEBYE-HÜCKEL PLASMA. S.R. Spielman and P.A. Vicharelli, GTE Labs, Inc

CB- 7 ELECTRON TRANSPORT AND RATE COEFFICIENTS NEAR BOUNDARIES. L.C. Pitchford, GTE Labs, Inc, P. Segur and M. Yousfi, U. Paul Sabatier, Toulouse, and T.J. Moratz, U. of Pittsburgh

CB- 8 PLASMA-SHEATH STRUCTURE FOR AN ELECTRODE CONTACTING AN ISOTHERMAL PLASMA: I. FORMULATION AND QUASI-NEUTRAL SOLUTION. S.A. Self and L.D. Eskin, Stanford U.

CB- 9 PLASMA-SHEATH STRUCTURE FOR AN ELECTRODE CONTACTING AN ISOTHERMAL PLASMA: II. AN ELECTRICALLY ISOLATED (FLOATING) ELECTRODE. L.D. Eskin and S.A. Self, Stanford U.

CB-10 ON THE SHEATH POTENTIAL IN RF-DISCHARGES. K.-U. Riemann, Ruhr -U. Bochum, W. Germany

CB-11 DOPPLER BROADENED LINE SHAPES OF ATOMIC HYDROGEN IN A PARALLEL PLATE RADIO FREQUENCY DISCHARGE. A.J. Capelli, R.A. Gottscho, and T.A. Miller, AT&T Bell Labs

CB-12 CATHODE PLASMA BEHAVIOR IN LONG PULSE, BROAD AREA ELECTRON BEAM DIODES. R.E. Shefer, R. Klinkowstein, J. Jacob, M. Tekula, Science Research Lab, Inc

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CB-17 A THEORY OF THE ELECTRODE SHEATH IN A RF DISCHARGE. V.A. Godyak, GTE Lighting Products

CB-18 THE SPATIAL AND TEMPORAL EVOLUTION OF THE GLOW IN A RF DISCHARGE. G.A. Hebner and J.T. Verdeyen, U. of Illinois at Urbana-Champaign

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CC- 3 INTERNAL ATTENUATION OF LASER RADIATION IN THE CuCl LASER. R.J. Niefer, J.B. Atkinson, and L. Krause, U. of Windsor, Ontario

CC- 4 ELECTRON BEAM INDUCED U. V. LASING AT ATMOSPHERIC PRESSURES. W.L. Atchison, USAF Academy and Lawrence Livermore Nat'l Lab, U. of California-Davis

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CC- 6 VERY SHORT LASER PULSES AND THE TWO-LEVEL ATOM: IS DETUNING RELEVANT? P.L. De Vries and J.F. Scipione, Miami U.

CC- 7 ELECTRON PRODUCTION BY PHOTOIONIZATION OF CS_2 AND SO_2 AT 193 nm. L.C. Lee and W.C. Wang, San Diego State U.

CC- 8 LASER MULTIPHOTON IONIZATION OF BENZENE. M.N. Spencer, J.S. Dickinson, D.J. Eckstrom, SRI Internat'l

CC- 9 RECYCLING OF OPTICAL RADIATION BY Xe FLASHLAMPS. C.E. Uhrich, K.S. Jancaitis, and H.T. Powell, Lawrence Livermore Nat'l Lab

CC-10 DEPENDENCE OF Xe FLASHLAMP EMISSION ON BORE DIAMETER AND INPUT POWER. K.S. Jancaitis, A.C. Erlandson, and H.T. Powell, Lawrence Livermore Nat'l Lab

CC-11 EFFECT OF PREIONIZATION ON Xe FLASHLAMP PERFORMANCE. A.C. Erlandson, C.E. Thompson, and H. T. Powell, Lawrence Livermore Nat'l Lab

CC-12 EXPERIMENT AND THEORY IN CONTINUOUS Xe ARCS AT MODERATE CURRENTS. P.J. Walsh and A. Kermani, Fairleigh Dickinson U. and Peak Systems

WEDNESDAY MORNING, 16 OCTOBER

DA: ELECTRON-MOLECULE COLLISIONS: ATTACHMENT

Chairperson: M. Dillon, Argonne Nat'l Lab

08:00 King Hall

DA- 1 MEASUREMENT OF CROSS SECTIONS FOR THE PRODUCTION OF NEGATIVE AND POSITIVE IONS BY ELECTRON IMPACT ON HCl, H_2O, CO, CO_2, NH_3, CH_4, and SiH_4. S.K. Srivastava and O.J. Orient, California Inst. of Tech

DA- 2 DISSOCIATIVE ELECTRON ATTACHMENT TO SO_2. S.M. Spyrou, I. Sauers, and L.G. Christophorou, Oak Ridge Nat'l Lab

DA- 3 DISSOCIATIVE ATTACHMENT IN VINYL AND ALLYL CHLORIDE. P.D. Burrow and K.L. Stricklett, U. of Nebraska-Lincoln

DA- 4 ELECTRON SCATTERING FROM LASER-PUMPED SF_6. K.L. Stricklett and P.D. Burrow, U. of Nebraska-Lincoln

DA- 5 ATTACHMENT PROPERTIES OF VIBRATIONALLY AND ELECTRONICALLY EXCITED GASES. M.J. Rossi, H.H. Helm, and D.C. Lorents, SRI Internat'l

DA- 6 MONTE CARLO CALCULATIONS ON THE RELAXATION OF INITIAL SECONDARY ELECTRONS IN ELECTRON BEAM SUSTAINED DISCHARGES CONTAINING ATTACHERS. G.F. Reinking, G. Schaefer, and K.H. Schoenbach, Texas Tech U

DB: HIGH PRESSURE ARC LAMPS
Chairperson: J. Maya, GTE Lighting Products
08:00 Ingersoll Hall, Rm. 122

DB- 1 ARC MODELS AND DIAGNOSTICS OF THE HIGH PRESSURE MERCURY ARC. R.P. Gilliard, General Electric Lighting Business Group, and J.T. Dakin, General Electric Corporate R&D

DB- 2 THE INFLUENCE OF XENON ON THE Na-D MAXIMA IN HIGH PRESSURE SODIUM ARCS. M.J. Jongerius, Philips Research Labs, Eindhoven

DB- 3 NEGATIVE LASER-INDUCED FLUORESCENCE IN HIGH-PRESSURE SODIUM ARCS. M.J. Jongerius and A.J.M.J. Ras, Philips Research Labs, Eindhoven

DB- 4 SPECTROSCOPIC MEASUREMENTS OF PULSED HIGH PRESSURE SODIUM DISCHARGE. N. Brates, and E.F. Wyner, GTE Sylvania Lighting Ctr.

DB- 5 INTENSITY OF SELF-REVERSED EMISSION LINES. P.A. Vicharelli, GTE Labs, Inc

DB- 6 THE WAVELENGTH DEPENDENCE OF THE ABSORPTION COEFFICIENT FOR THE SODIUM RESONANCE LINE AS MEASURED BY LASER ABSORPTION IN A HIGH PRESSURE SODIUM ARC. A.K. Bhattacharya, T.P. Benson, and A. Baker, General Electric Co

DB- 7 MEASUREMENT OF THE SODIUM DENSITY IN A HIGH PRESSURE SODIUM ARC AND THE Na 514 nm TRANSITION PROBABILITY. T.P. Benson and A.K. Bhattacharya, General Electric Co

EA: ION-MOLECULE REACTIONS
Chairperson: R. Johnsen, U. of Pittsburgh
10:00 King Hall

EA- 1 THE NATURE OF THE $O_2^+ + CH_4 \rightarrow CH_3O_2^+ + H$ PRODUCT ION. J.M. Van Doren, S.E. Barlow, V.M. Bierbaum, C.H. DePuy, I. Dotan, and E.E. Ferguson, U. of Colorado and NOAA

EA- 2 INTERNAL ENERGY EFFECTS IN BIMOLECULAR ION-MOLECULE REACTIONS. P.R. Kemper, J. Pearson, T. O'Keefe, and M.T. Bowers, U. of California-Santa Barbara

EA- 3 PREDICTING THE TEMPERATURE DEPENDENCES OF ION-MOLECULE ASSOCIATION REACTIONS IN THE LOW PRESSURE LIMIT. A.A. Viggiano and J.F. Paulson, Hanscom AFB

EA- 4 INVESTIGATION OF MECHANISMS OF CHARGE TRANSFER REACTIONS USING CROSSED MOLECULAR BEAMS. Du Wen Hu, B. Friedrich, A. Rockwood, S. Howard, P. Tosi, W. Lindinger, and J.H. Futrell, U. of Utah

EA- 5 THE REACTIONS OF $Ar^+(^2P_{3/2})$ AND $Ar^+(^2P_{1/2})$ WITH O_2 FROM 0.04 eV TO 3 eV. M. Hamdan, K. Birkinshaw, U. of Wales, United Kingdom

EA- 6 MOLECULAR DYNAMICS STUDIES OF THE CHARGE TRANSFER REACTION $Ar^+(^2P_{3/2}) + N_2(\Sigma_g, v=0) = N_2^+(^2\Sigma_g) + Ar(^1S_o)$ AT LOW AND INTERMEDIATE ENERGIES. J.H. Futrell, A. Rockwood, S. Howard, Y.T. Long, P. Tosi, A. Shukla, and K. Birkinshaw, U. of Utah

EA-7 STRONG ACIDS AND HIGH ELECTRON AFFINITIES. J.F. Paulson, A.A. Viggiano, and M. Henchman, Hanscom AFB

EB: DC - GLOWS
Chairperson: A.K. Bhattacharya, General Electric Co
10:00 Ingersoll Hall, Rm. 122

EB- 1 PROFILE OF VIBRATIONAL TEMPERATURE IN AN AXIALFLOW, LONGITUDINAL N_2 DISCHARGE. S. Ono and S. Teii, Musashi Institute of Tech., Japan

EB- 2 SPATIAL DEPENDENCE OF LIGHT EMISSION FROM N_2 DISCHARGES AT VERY HIGH E/n. B. Jelenkovic and A.V. Phelps, JILA, U. of Colorado and NBS

EB- 3 OPTOGALVANIC SPECTROSCOPIC MEASUREMENT OF THE ELECTRIC FIELD VECTOR IN A POSITIVE COLUMN DC DISCHARGE. B.N. Ganguly and A. Garscadden, Air Force Wright Aeronautical Labs

EB- 4 RADIAL DISTRIBUTION OF MERCURY ISOTOPES IN A LOW PRESSURE Hg-Ar DISCHARGE. M.W. Grossman, R. Lagushenko, and J. Maya, GTE Lighting Products

EB- 5 MAGNETIC CONTROL OF LOW PRESSURE GAS DISCHARGES. J.R. Cooper and K.H. Schoenbach, Old Dominion U.-Norfolk and G. Schaefer, Texas Tech U.

EB- 6 THYRATRON MODELING USING A PLASMA PARTICLE SIMULATION. M.J. Kushner, R.A. Petr, and C.H. Fisher, Spectra Technology, Inc

EB- 7 RAPID ANALYSIS OF DISCHARGE KINETICS DATA IN EXTERNALLY SUSTAINED DISCHARGES. M. von Dadelszen, Tetra Corp

EB- 8 AN ANALYSIS OF THE CATHODE SPOT DISTRIBUTIONS IN HIGH PRESSURE, EXTERNALLY SUSTAINED GLOW DISCHARGES. M. von Dadelszen, Tetra Corp

WEDNESDAY AFTERNOON, 16 OCTOBER

FA: ELECTRON-MOLECULE COLLISIONS: TOTAL SCATTERING AND EXCITATION

Chairperson: R. St. John, U. of Oklahoma-Norman

13:00 King Hall

FA- 1 MEASUREMENTS AND CALCULATIONS OF ELECTRON BEAM GROWTH IN N_2. P.C.F. IP, and W.A.M. Blumberg, Hanscom AFB, B.D. Green, W.J. Marinelli, and G.E. Caledonia, Physical Sciences Inc

FA- 2 RELATIVE EXCITATION EFFICIENCIES OF N_2 ELECTRONIC STATES. B.D. Green and W.J. Marinelli, Physical Sciences Inc, and W.A.M. Blumberg, Hanscom AFB

FA- 3 LOW-ENERGY, SMALL-ANGLE SCATTERING OF ELECTRONS BY ALKALI-HALIDE MOLECULES. G.F. Shen, M. Zuo, B. Stumpf, B. Jaduszliwer, and B.Bederson, New York U.

FA- 4 VIBRATIONAL EXCITATION OF HF MOLECULES BY SLOW ELECTRON IMPACT: EFFECTS OF POLARIZATION. A. Jain and D.W. Norcross, U. of Colorado and NBS

FA- 5 ABSOLUTE LOW ENERGY DIFFERENTIAL ELASTIC SCATTERING CROSS SECTIONS IN He and H_2. D.E. Golden, North Texas State U.

FB: PLASMA CHEMISTRY

Chairperson: R.A. Gottscho, AT&T Bell Labs

13:00 Ingersoll Hall, Rm. 122

FB- 1 EXTRACTION OF VOLUME-PRODUCED H^- IONS. M. Bacal and F. Hillion , Ecole Polytechnique, France

FB- 2 ELECTRON KINETICS IN LOW PRESSURE SF_6 ETCHING DISCHARGES. L.E. Kline, Westinghouse R&D

FB- 3 CHEMICAL KINETICS IN LOW PRESSURE SF_6 ETCHING DISCHARGES. L.E. Kline, Westinghouse R&D

FB- 4 MEASURED AND PREDICTED α - C: H DEPOSITION RATES IN RF DISCHARGES IN CH_4. L.E. Kline and W.D. Partlow, Westinghouse R&D

FB- 5 MECHANISTIC STUDY OF REACTIVE ION ETCHING OF Si and SiO_2. G. Fortuno, IBM East Fishkill

FB- 6 APPLICATIONS OF THE NEW KINETIC MANY-BODY THEORY OF INTERACTIONS OF LOW ENERGY PLASMA PARTICLES WITH SURFACES. Yu L. Khait, Ben Gurion U., Israel

G: SYMPOSIUM ON ION-MOLECULE REACTIONS

Moderator: E.E. Ferguson, NOAA

14:45 King Hall

G- 1 PRODUCTION AND LOSS PROCESSES IN LOW TEMPERATURE PLASMAS. D. Smith, U. of Birmingham

G- 2 EFFECT OF ION INTERNAL STATES ON ION-MOLECULE REACTIONS. R. Zare, Stanford U.

G- 3 TRANSLATIONAL AND ELECTRONIC ENERGY DEPENDENCE OF ION-MOLECULE REACTIONS. P. Armentrout, U. of California-Berkeley

G- 4 THREE-BODY ION MOLECULE REACTIONS. R. Johnsen, U. of Pittsburg

THURSDAY MORNING, 17 OCTOBER

H: BREAKDOWN
Chairperson: J. Proud, GTE Labs
08:00 King Hall

H- 1 WAVE STRUCTURE IN PROGRESSIVE BREAKDOWN. M. Hemmati and R.G. Fowler, U. of Oklahoma

H- 2 WATER VAPOR-ENHANCED ELECTRON AVALANCHE GROWTH IN SF_6 FOR NONUNIFORM FIELDS. R.J. Van Brunt, Nat'l Bureau of Standards

H- 3 TRANSIENT IONIZATION AND EXCITATION RATES AT HIGH E/N. G.N. Hays, L.C. Pitchford, J.B. Gerardo, and J.T. Verdeyen, Sandia Nat'l Labs

H- 4 OPERATION OF EXTERNALLY IONIZED DISCHARGES OF HIGH ELECTRIC FIELDS. P. Bletzinger, AF Wright Aeronautical Labs

H- 5 APPLICATIONS TO PULSED GAS DISCHARGES AND LASERS OF THE NOVEL STATISTICAL KINETIC THEORY OF TRANSIENT ELECTRONIC PHENOMENA IN GASES IN ELECTRIC FIELDS. Yu. L. Khait, Ben Gurion U., Israel

H- 6 PLASMA CHANNEL FORMATION OVER ELECTRICALLY HEATED SILICON FILMS. D.A. Benson and R.W. Bickes, Jr., Sandia Nat'l Labs

I: LOEB COMMEMORATIVE SESSION
Chairperson: L. Fisher
09:50 King Hall

I- 1 EARLY WORK ON ELECTRICAL BREAKDOWN IN GASES. L. Fisher

I- 2 VIOLATIONS OF PASCHEN'S LAW. L.G. Christophorou and S.R. Hunter, Oak Ridge Nat'l Lab

I- 3 IONIZATION ATTACHMENT AND LIMIT FIELDS IN SF_6/N_2 AND SF_6/CCl_2F_2 MIXTURES. M.F. Fréchette, IREQ, Québec

I- 4 SMALL SPARKS AND CATHODE SPOTS. G. Barreto and E. Barreto, SUNY-Albany

I- 5 THE FORMATION AND PROPAGATION OF AVALANCHES AND STREAMERS IN ELECTRONEGATIVE GASES. C. Wu and E.E. Kunhardt, Polytechnic Instit. of New York

I- 6 COMMON PARAMETERIZATIONS OF ELECTRON SWARM AND BREAKDOWN DATA FOR BINARY GAS MIXTURES. R.J. Van Brunt and M.C. Siddagangappa, Nat'l Bureau of Standards

I- 7 COMPUTATION OF THE RADIUS OF A HIGH PRESSURE FILAMENTARY DISCHARGE IN AIR DURING AN EARLY STAGE OF THE CHANNEL DEVELOPMENT. H. Jurenka and E. Barreto, SUNY-ALBANY

THURSDAY AFTERNOON, 17 OCTOBER

JA: HEAVY PARTICLE COLLISIONS
Chairperson: R. Varney
13:30 King Hall

JA- 1 VARIATIONAL PRINCIPLE FOR ASSOCIATION/DISSOCIATION IN DENSE GASES. M.R. Flannery, Georgia Tech

JA- 2 ELECTRONIC STRUCTURE AND REACTIVITY OF C_2^+ AS SEEN BY FOURIER TRANSFORM MASS SPECTROSCOPY. A. O'Keefe and J.R. McDonald, Naval Research Lab, D.C.

JA- 3 ANALYSIS OF QUINTET He_2^* FORMATION THROUGH COLLISIONS OF TRIPLET METASTABLE HELIUM ATOMS. H.H. Michels, United Technologies Research Ctr

JA- 4 ROTATIONAL ENERGY TRANSFER IN THE ELECTRONICALLY EXCITED $B\,^3\Pi_g$ State OF N_2. D.H. Katayama, Hanscom AFB

JA- 5 LONG-LIVED STATES IN NITROGEN AFTERGLOWS. L.G. Piper and G.E. Caledonia, Physical Sciences Inc

JA- 6 VELOCITY DEPENDENT TOTAL SCATTERING CROSS SECTION FOR $Ar(^3P_{2,0})$ on N_2. K.A. Hardy and J.W. Sheldon, Florida Internat'l U.

JA- 7 POSITIVE ION MOBILITIES AND REACTIONS IN NH_3 GAS. Z.A. Talib and M. Saporoschenko, Southern Illinois U.-Carbondale

JB: IONIZATION AND ELECTRON HEATING
Chairperson: G.N. Hays, Sandia Nat'l Labs
13:30 Ingersoll Hall, Rm. 122

JB- 1 MICROWAVE CONDUCTIVITY MEASUREMENTS OF ELECTRON-BEAM-IONIZED AIR AFTERGLOWS. M.N. Spencer, J.S. Dickinson, and D.J. Eckstrom, SRI Internat'l

JB- 2 ELECTRON HEATING IN MICROWAVE-AFTERGLOW PLASMAS. B.M. Penetrante and J.N. Bardsley, U. of Pittsburgh

JB-3 LASER HEATING OF LOW TEMPERATURE PLASMAS WITH APPLICATION TO ENERGY CONVERSION. N.W. Jalufka, NASA Langley Research Ctr

JB- 4 STATISTICAL MECHANICS OF RYDBERG ATOMS. D.L. Huestis, SRI Internat'l

JB- 5 TWO-TEMPERATURE ANALOG TO THE SAHA EQUATION. P.A. Vicharelli and A.V. Phelps, U. of Colorado

JB- 6 COLLISIONAL-RADIATIVE RECOMBINATION AND NET IONIZATION IN MERCURY VAPOR. J.M. Anderson, General Electric Corporate R&D

JB- 7 THE ROLE OF NEUTRAL-NEUTRAL INELASTIC COLLISIONS IN A LOW-TEMPERATURE PLASMA. J.A. Kunc, U. of Southern California

KA: GAS LASERS
Chairperson: H.T. Powell, Lawrence Livermore Nat'l Lab
15:30 King Hall

KA- 1 HIGH PRESSURE, PULSED RADIAL GLOW DISCHARGES FOR CO_2 LASERS. C.M. Young, B.R. Beckes, T.J. Beezhold, J.W. Benze, J.M. Elizondo, W.M. Moeny, and J.G. Small, Tetra Corp

KA- 2 CW RECOMBINATION LASERS IN ELECTRON BEAM GENERATED PLASMAS. J.J. Rocca, B. Wernsman, and H.L. Mancini, Colorado State U.

KA- 3 HIGH EFFICIENCY KrF* LASER USING ELECTRON BEAM SUSTAINED DISCHARGE PUMPING OF Kr/F_2 LASER MIXTURES. E.T. Salesky and S. Singer, Los Alamos Nat'l Lab

KA- 4 TEMPERATURE DEPENDENCE MEASUREMENTS OF Kr_2F^* FLUORESCENCE IN KrF* LASER MIXTURES. W.D. Kimura, Spectra Technology, Inc, and E.T. Salesky, Los Alamos Nat'l Lab

KA- 5 ANALYSES OF XeF GROUND STATE KINETICS. T.T. Yang, J.A. Blauer, and C.E. Turner,Jr., Rockwell Internat'l

KA- 6 SOLAR PUMPED LASING OF $n\text{-}C_4F_9I$ AND $i\text{-}C_3F_7I$. R. De Young, NASA Langley Research Ctr

KB: SHEATHS AND DISTRIBUTION FUNCTIONS
Chairperson: S.A. Self, Stanford U.
15:30 Ingersoll Hall, Rm. 122

KB- 1 THE ENERGY DISTRIBUTION OF ELECTRONS IN A PROPAGATING GLOW DISCHARGE BEAM. B-X. Shi, Z. Yu, K. Jayaram, and G.J. Collins, Colorado State U.

KB- 2 THREE-TERM APPROXIMATION OF THE BOLTZMANN EQUATION FOR N_2 AT HIGH E/N. M.N. Fréchette and J.P. Novak, IREQ, Québec

KB- 3 PRIMARY ELECTRON ENERGY LOSS IN THE NEGATIVE GLOW OF A Hg/Ar LOW PRESSURE ARC. J.M. Anderson, General Electric R&D Ctr

KB- 4 STEADY-STATE CHARACTERISTICS OF A HYDROGEN THYRATRON DISCHARGE. B.M. Penetrante, E.E. Kunhardt, and E. Levi, Polytechnic Instit. of New York

KB- 5 THEORY OF RUNAWAY ELECTRONS IN A WEAKLY IONIZED PLASMA. K.-U. Riemann, Ruhr-U. Bochum, W.Germany

KB- 6 ASYMPTOTICALLY CORRECT COLLISIONAL PRESHEATHS. G.L. Main, Georgia Instit. of Tech

KB- 7 PLASMA PROFILES IN LOW PRESSURE DC DISCHARGES. J.P. Hauck, E.H. Huffman, and R.J. Blair, California State U.-Fullerton

FRIDAY MORNING, 18 OCTOBER

LA: R-F DISCHARGES
Chairperson: L.C. Pitchford, GTE Labs, Inc
08:30 King Hall

LA- 1 NEGATIVE ION KINETICS IN RADIO FREQUENCY GLOW DISCHARGES. C.E. Gaebe and R.A. Gottscho, AT&T Bell Labs

LA- 2 AXIAL PLASMA DENSITY AND ELECTRON TEMPERATURE PROFILES OF RING TYPE CAPACITANCE COUPLING FLOWING RF GLOW DISCHARGE ARGON PLASMA. J.S. Chang, A. Arishima, S. Matsumura, McMaster U. and S. Teii, Musashi Instit. of Tech, Japan

LA- 3 A MODEL FOR THE BULK PLASMA IN AN RF CHLORINE DISCHARGE. G.L. Rogoff, J.M. Kramer, and R.B. Piejak, GTE Labs Inc

LA- 4 MOTION OF INTENSITY LAYERS IN AN RF PARALLEL PLATE DISCHARGE AT 13.56 MH_Z. P. Bletzinger and C.A. DeJoseph, Jr., AF Wright Aeronautical Labs

LA- 5 PARTICLE DISTRIBUTIONS AND LASER-PARTICLE PHOTOPHYSICS IN AN RF DISCHARGE OF SILANE IN ARGON. K.G. Spears, T.J. Robinson, and R.M. Roth, Northwestern U.

LB: ARCS AND SWITCHING
Chairperson: J. Anderson, General Electric R&D Ctr
08:30 Ingersoll Hall, Rm. 122

LB- 1 MECHANISM OF ARC COMMUTATION IN SWITCHING DEVICES. K.-P Nachtigall, Ruhr -U. Bochum, W. Germany

LB- 2 SPECTROSCOPIC INVESTIGATIONS OF A LOW CURRENT ARC IN FLUORINE. H.-L. Hausmann, Ruhr -U. Bochum, W. Germany

LB- 3 NEW TRANSITION PROBABILITY SCALE FOR ARGON. A. Sedghinasab, T.L. Eddy, Georgia Instit. of Tech

LB- 4 TEMPERATURE MEASUREMENTS OF A DYNAMIC TURBULENT NITROGEN ARC IN HIGH SPEED FLOW. U. Sen and D.M. Benenson, SUNY-Buffalo

LB- 5 PROPERTIES OF ARCS IN THE BOUNDARY LAYER OF AN MHD GENERATOR OR ACCELERATOR. R.J. Rosa, Montana State U.

LB- 6 UNIPOLAR ARCS. F. Schwirzke, Naval Postgraduate School

M: INVITED LECTURES
Chairperson: D.L. Huestis, SRI Internat'l
10:30 King Hall

M- 1 FREE ELECTRON LASERS. J. Slater, Spectra Technology, Inc

M- 2 SPACECRAFT GLOWS. T.G. Slanger, SRI Internat'l

SESSION A

08:25, Tuesday, October 15, 1985

ELECTRON-MOLECULE COLLISIONS: EXCITATION

Chairperson: R.S. Freund
AT&T Bell Labs

A-1 Vibrational and Electronic Excitation of Molecules (atoms) by Electron Impact, D. C. CARTWRIGHT, Los Alamos Nat'l Lab and S. TRAJMAR, Cal Tech Jet. Prop. Lab - The progress made in determining new cross sections for a wide variety of electron-impact processes has been impressive the past ten years. This talk will summarize some of the recent experimental and theoretical results that have been obtained on electron-impact excitation of molecules (atoms). The focus in this summary will be on electronic and vibrational excitation of selected atoms, diatomic and triatomic molecules of current interest, in the few eV to a few 100 eV impact energy range. In addition to discussing new data and analysis on inelastic electron scattering by N_2 and CO_2, we will outline the need for more accurate electron collision data in order to better understand gas discharges in inert gas/halogen mixtures.

A-2 Dissociative Excitation of the Oxygen and Nitrogen Molecules by Electron Impact,* CHUN C. LIN, L. W. ANDERSON, F. A. SHARPTON, A. R. FILIPPELLI,† M. B. SCHULMAN, and D. L. A. RALL, U. of Wisconsin--Electron-impact dissociative excitation of the oxygen and nitrogen molecules is studied by measuring the emission of the excited atoms produced by an electron beam incident on the molecular gas. Optical emission excitation cross sections for about a hundred emission lines of the N and O atoms have been measured with electron energy from threshold to 500 eV. The excitation cross section data are used to analyze the mechanisms for dissociative excitation and to identify the key excited molecular states involved. Optical cross sections for the N^+ emission lines are also reported. The results are compared with those of the neutral-atom emission lines and the mechanisms for producing excited N^+ ions are discussed.

*Work supported by the Air Force Office of Scientific Research.

†Present address: National Bureau of Standards, Gaithersburg, Maryland.

A-3 Electron Impact Excitation of Infrared-Active Modes in Linear Molecules,* E.S. CHANG, U of Massachusetts, Amherst--High resolution crossed beam measurements of vibrational excitations have recently been completed[1] in CO, CO_2, and C_2H_2. The electron energy ranges from the threshold to the low-energy resonance regions of a few eV. As described in a forthcoming comment[2], all differential cross sections for the infrared-active modes are found to agree well with a theory which unifies direct and resonant scattering. In particular, direct vibrational excitation in the threshold energy region is simply related to the infrared absorption intensity, and the rovibrational structures to the Hönl-London factors of spectroscopy. Raman-active cross sections will be presented and some theoretical interpretations will be discussed.

*Work supported in part by Deutsches Forschungsgemeinschaft.

[1]K.H. Kochem, W. Sohn, K. Jung, H. Ehrhardt, and E.S. Chang, J. Phys. B 18, 1253 (1985), and references.

[2]E.S. Chang, Comm. Atom. & Molec. Phys. (in press).

SESSION B

10:10, Tuesday, October 15, 1985

XUV LASERS

Chairperson: W.L. Morgan
Lawrence Livermore Nat'l Lab

B

B-1 VUV and X-Ray Lasers: An Overview of Progress. Ronald W. Waynant, Naval Research Laboratory, Washington, DC 20375. In a review paper nearly ten years ago the fundamental difficulties and approaches available in building an x-ray laser were spelled out. These principles remain valid today and set the stage for an understanding of today's exciting research. This talk will review the basic principles involved in x-ray laser production; sumarize the results to date; and set the stage to facilitate understanding the presentations to follow in the program.

B-2 Demonstration of a Soft X-Ray Amplifier* J.E. TREBES, Lawrence Livermore National Laboratory, University of California, Livermore, CA 94550 -- Soft x-ray amplified spontaneous emission has been observed from exploding foil targets irradiated at the Novette laser facility of the Lawrence Livermore National Lab. These foils of selenium were irradiated at intensities of $5X10^{13}$ W/cm^2 producing plasma conditions suitable for population inversions on the $2p^53p$-$2p^63s$ transitions in the neon-like Se ion. Using three independent types of time-resolved, high resolution spectroscopic diagnostics, substantial amplification with gail-length products up to 6 were demonstrated. Gain coefficients of $5.5 + 1.0$ cm^{-1} on the J=2 to 1 transition at 206.3 and 209.6 Å were obtained. Scaling to higher Z was accomplished with yttrium. Progress toward saturation will be discussed.

*Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

B-3 Progress Toward a VUV Laser in Xenon III*, R. Falcone, Physics Dept. U.C. Berkeley-- Lifetime measurements and preliminary gain measurements have been made on a new Vacuum Ultraviolet (VUV) laser system in Xenon III at 1089 Å. Soft x-rays produced by a laser plasma cause 4d ionization in neutral Xenon gas. Subsequent Auger decay produces a population inversion in Xenon III. This type of laser inversion scheme was initially proposed by McGuire[1].
*Work supported by the National Science Foundation and Lawrence Livermore National Laboratory.
(1) E. McGuire, Phys. Rev. Lett. 35, 844 (1975)

B-4 Resonant Photo-excitation in CIII with MnVI Line Radiation,* M. KRISHNAN, Physics International Co., San Leandro, CA-- A class of photo-excited lasers from 2177 to 200 Å in Be-like ions has been proposed.[1] In one scheme, CIII ions in a vacuum-arc discharge are resonantly pumped to the 4p $^1P^0$ level by MnVI line radiation at 310.18 Å from an adjacent, laser produced plasma. Enhanced fluorescence in CIII at 1620, 1923, 2163, and 2177 Å has been measured.[2] Spatially resolved measurements have been made of n_e and T_i in the vacuum-arc discharge. Using recent atomic data,[3] a collisional-radiative model of CIII is compared with the measurements for different MnVI pump intensities. This paper describes the research at Yale and comments on scaling of this prototype scheme to soft x-ray analogs, such as MgIX pumped by AlXI.

*Research (in collaboration with H. Kilic and N. Qi) supported by AFOSR Grant No. 81-0077.
[1]M. Krishnan and J. Trebes, Appl. Phys. Lett. 45, 189 (1984).
[2]N. Qi, H. Kilic, and M. Krishnan, Appl. Phys. Lett. 46, 471 (1985).
[3]Atomic data provided by Dr. W.L. Morgan, LLNL.

SESSION C

14:00, Tuesday, October 15, 1985

POSTERS

CA: COLLISIONS

CB: DISCHARGES

CC: PHOTONICS

Chairperson: F. Schwirzke
Naval Postgraduate School

CA-1 Electron Attachment to SO_2 and CS_2 in Ar, N_2, and CH_4,* W.C. WANG and L.C. LEE, San Diego State University,--The attachments of electrons to SO_2 and CS_2 in Ar, N_2 and CH_4 (pressure ranges from 150 to 530 torr) are investigated using a parallel-plate drift-tube apparatus, where the initial electrons are produced by irradiating the cathode with KrF laser photons. The measured electron attachment rate constant in the SO_2-Ar mixture increases with increasing E/N and does not depend on buffer gas pressure. However, the attachment rate constants in the SO_2-N_2 and SO_2-CH_4 mixtures decrease with increasing E/N and depend on the buffer gas pressures. The electron attachment processes of CS_2 in N_2 and CH_4 buffer gases were investigated. The attachment rate ν_a of CS_2 shows a pressure dependence to be $\nu_a = k[CS_2]^2 + k'[CS_2][M]$, where k and k' are the three body attachment rate constants and M is either N_2 or CH_4. Both k and k' decrease with increasing E/N whose values will be reported in the conference.

*Work supported by Air Force Office of Scientific Research under Grant No. AFOSR-82-0314.

CA-2 Electron Drift Velocity and Attachment and Ionization Coefficients in C_2F_6/Ar and C_2F_6/CH_4 Gas Mixtures at Elevated Gas Temperatures,* J. G. CARTER, S. R. HUNTER, and L. G. CHRISTOPHOROU, Oak Ridge National Laboratory--The temperature dependences of the transport and rate coefficients of recently discovered gas mixtures for diffuse discharge opening switch applications[1] are required for modeling studies of the operating characteristics of the switch under repetitive operation. Measurements of the electron drift velocity w, attachment coefficient η/N, and ionization coefficient α/N have been made in C_2F_6/Ar and C_2F_6/CH_4 gas mixtures over the temperature range $300 \leq T \leq 700$ K and concentration range of 0.1 to 100% of the C_2F_6. In pure C_2F_6 w decreases with increasing T, and this effect diminishes with increasing Ar or CH_4 concentration. In contrast, η/N increases with T for all concentrations of C_2F_6 in Ar and CH_4. These observations are interpreted in terms of the electron scattering and attaching properties of C_2F_6 as a function of T.

*Research sponsored in part by OHER, USDOE, under contract DE-AC05-84OR21400 and in part by ONR under agreement 43 01 24 60 2 with Martin Marietta Energy Systems, Inc.

[1]S. R. Hunter, J. G. Carter, and L. G. Christophorou, J. Appl. Phys. (in press).

CA-3 Recombination of Ar_2^+ Ions with Electrons in Atmospheric-Pressure Ambient Helium,* R. Johnsen and H. S. Lee, U. of Pittsburgh -- A newly developed rf-probe technique in conjunction with mass-spectrometric sampling of ions has been employed for studies of the electron-density decay in uv-photoionized He-Ar gas mixtures at pressures from 0.5 to 1 at. Ar_2^+ was found to be the dominant ionic species under these conditions and the decay of the electron density was shown to be due to recombination. The inferred recombination coefficients were 7.5 ± 1 (-7) cm^3/s, independent of helium pressure between 0.5 and 1 at. The results are quite close to those obtained in conventional low-pressure afterglows, indicating both the reliability of the new method and the absence of a significant third-body effect on electron-ion recombination in high-pressure helium.

*Work supported, in part, by the Army Research Office.

CA-4 Electron-Ion Recombination Rates in an Atmospheric Pressure Plasma,* S.M. JAFFE, M. MITCHNER, S.A. SELF, Mechanical Engr. Dept., Stanford Univ. -- A design is presented for an experiment to measure the rate of the three body recombination reaction $A^+ + e^- + M \rightarrow A + M$, where A^+ is an alkali metal ion and M is a molecule. The experiment employs an equilibrium mixture of up to 20 torr of Cs and 1000 torr of N_2 at temperatures ranging from 1000 to 1500 K. Selective photoionization from a Xenon flashlamp with wavelengths in the range 200-318 nm is used to produce a partially ionized plasma (0.1%) with electron number density $\sim 10^{11}$ cm^{-3}, which is in thermal, but not in chemical equilibrium. Electron concentration is monitored by a four pin conductivity probe during the first 10 ms of relaxation. A detailed analysis of competing electron loss mechanisms (ion-molecule and recombination reactions are considered) indicates that electron concentration decay can be directly linked to recombination stabilized on the N_2.

*Work supported by the AFOSR, Grant 83-0108.

CA-5 Vibrational Excitation of Diatomic Molecules (N_2, CO, Li_2) during Resonance Scattering of Electrons,* J.M. WADEHRA and P.J. DRALLOS, Wayne State University--
A one dimensional integral expression is obtained for the cross section for resonant vibrational excitation of diatomic molecules. The potential energy curves for both the neutral molecule as well as the resonant state are approximated by one dimensional harmonic oscillators having arbitrary curvatures and equilibrium positions. Results of the computations are obtained for the molecules N_2 and CO, and are in good agreement with experiment. Results for resonant vibrational excitation cross sections for Li_2 are also presented.

*Work supported by AFOSR Grant 84-0143

CA-6 Excitation of Neon $2p^5 3p$ Levels by Low Energy Electron Beams,* M. BRUCE SCHULMAN, FRANCIS A. SHARPTON, L.W. ANDERSON, and CHUN C. LIN, U. of Wisconsin-Madison
Electron beams with energy below threshold for the $2p^5 3p$ levels can excite these levels in a two-step process through a metastable $2p^5 3s$ level. Neon atoms in the metastable levels are generated by an electron beam of energy about 17 eV. The metastable atom density is obtained by pumping the metastable atoms to a 2p level ($2p^5 3p$ configuration) with a laser and observing the laser-induced fluorescence from the 2p level. The energy of the electron beam is modulated so as to alternate between 17 eV and about 6 eV. During the low-energy cycle metastable atoms are excited to the 2p levels by the 6 eV electron beam, and the effect of this on the $2p \rightarrow 1s$ radiation is observed at various delays after the electron beam energy is switched from 17 eV to 6 eV.

*Work supported by the Air Force Office of Scientific Research.

CA-7 Energy Loss Spectroscopy of Xenon Difluoride,* MICHAEL DILLON, HIROSHI TANAKA, and DAVID SPENCE, Argonne National Laboratory -- Electron impact spectra of XeF_2 have been recorded using electrons of 200 eV incidence at scattering angles of $\sim$ 2°-9°. The range of energy losses, 4-23 eV, covers the region of single electron excitation from the valence shell. Both valence and Rydberg transitions have been observed and tentatively identified.

*Work supported by the U. S. Department of Energy.

CA-8 Measurements of the Absolute Cross Sections for Ionization and Fragmentation of SiF_3, SiF_2, SiF, and Si by Electron Impact TODD R. HAYES, ROBERT C. WETZEL, AND ROBERT S. FREUND AT&T BELL LABORATORIES -- Absolute ionization and dissociative ionization cross sections of the free radicals SiF_3, SiF_2, and SiF, and ionization of atomic Si have been measured from threshold energy to 200 eV. The experimental technique crosses a fast beam of the reactive species with an electron beam. The apparatus is designed to mass-separate and completely collect the ionic dissociation fragments. A pure beam of the neutral radical or atom is prepared from a mass filtered ion beam by charge transfer neutralization in a low pressure gas. The degree of rovibronic excitation of the molecular species varies according to the method of preparation. The effects of such internal energy on the absolute cross sections and fragmentation patterns will be described.

CA-9 Measurement of the atomic fraction and atomic temperature in H_2 magnetic multicusp discharges by translational spectroscopy. M. BACAL and F. HILLION, Ecole Polytechnique. The high resolution spectrum of the Balmer-β line observed from an H_2 magnetic multicusp discharge shows a relatively narrow central peak and broad wings. We propose to use this property to determine the ratio of atomic/molecular hydrogen densities. The method is based on the possibility to separate by high resolution spectroscopy the fast component of excited H(n=4) from the slow component. The fast component is identified as the fast group produced by dissociative excitation of molecular hydrogen by electrons. The slow component contains two contributions : from dissociative excitation and from the excitation of ground state atomic hydrogen. This method can be applied to any discharge provided the electron energy distribution function and the pumping rates for producing H(n=4) are known. The relative intensity for the formation of the slow and fast H*(n=4) groups in dissociative excitation by electrons of various energies, reported by Higo et al, is essential.

M. Higo, S. Kamato and T. Ogawa, Chem. Phys., 73, 99 (1982).

CA-10 Vibrational excitation in magnetic multicusp H_2 discharges. C. GORSE, M. CAPITELLI, University of Bari, J. BRETAGNE, Université de Paris-Sud, M. BACAL, Ecole Polytechnique. Vibrational excitation of H_2 in magnetic multicusp H_2 discharges is of primary importance for understanding the production of negative ions through dissociative electron attachment. We have built a theoretical model which at the same time solves : 1) the Boltzmann equation for the electron energy distribution function, ; 2) the vibrational kinetics including the most important pumping and deactivating processes ; 3) the plasma chemistry describing the dissociation process. The vibrational kinetics takes into account both pumping by low energy electron collisions and by singlet excitation collisions due to electrons with a few tens of eV, and the deactivation of vibrational energy by V-T energy exchange involving molecular and atomic hydrogen. Wall deactivation of vibrational energy as well as heterogeneous atom recombination are taken into account. The theoretical results, which refer to a 40 mTorr, 90 V, 1-10 A H_2 discharge, are in satisfactory agreement with the experimental results.

CB-17 A Theory of the Electrode Sheath in a RF

CA-11 Electron Excitation Processes In Hydrogen Negative Ion Discharges* J.R. HISKES, A.M. KARO, and T. DeBONI, LLNL --The interpretation of negative ion generation in hydrogen discharges requires the calculation of the $H_2(v'')$ vibrational distribution followed by the calculation of electron attachment to these molecules giving rise to dissociative attachment.[1] In the lower portion of the vibrational spectrum the population is in equilibrium through the electron excitation via the negative ion resonance and collisional relaxation with the walls. Wall relaxation has been studied using appropriate metal cluster/hydrogen potentials. A movie of vibrational relaxation will be shown. The upper portion of the vibrational spectrum is in equilibrium with electronic excitation through the $B'\Sigma_u$ and $C'\Pi_u$ states followed by destruction via singlet and triplet electronic excitation from the individual vibrational levels. Excitation cross sections to the singlet states will be presented. Discharge configurations for optimum negative ion generation are discussed.

*Performed by LLNL for U.S.D.O.E. under contract W-7405-ENG-48.

[1]J.R. Hiskes, A.M. Karo, J. Appl. Phys. 56 (7), 1927 (1984)

CA-12 Autodetached Electron Energy Spectrum from Metastable He_2^-, Y. K. BAE AND J. R. PETERSON, Molecular Physics Department, SRI Int.-- The energy spectrum of autodetached electrons from the metastable He_2^- ion has been measured. Rapid autodetachment of this $^4\Pi_g$ ion[1,2] to the $^1\Sigma_g^+$ He^2 ground state is forbidden by its spin configuration, as in the case of He^-. He_2^- ions were produced from 4.1 keV He_2^+ by two-step electron capture in Cs vapor.[1] The electron energy spectrum is single-peaked continuum with a maximum at 15.7 eV, resulting from a vertical transition to the repulsive wall of the He_2 ground state. These preliminary result indicate disagreement between the calculated[2] location the He_2^- potential and the experimentally deduced He_2 potential of Foreman, et al.[3]

*Supported by NSF and AFOSR.

1. Y. K. Bae, M. J. Coggiola, and J. R. Peterson, Phys Rev. Lett. 52, 747 (1984).
2. H. H. Michels, Phys. Rev. Lett. 52, 1413 (1984).
3. P. B. Foreman, P. K. Rol, and K. P. Coffin, J. Phys Chem. 61. 1658 (1974).

CA-13 Positron-SiH_4 Scattering (0.1-6 eV).* A. JAIN,† JILA, U. of Colo. & NBS and D.G. THOMPSON, Dept. Appl. Math., Queen's Univ. Belfast--Positron (e^+)-SiH_4 scattering below positronium (Ps) formation is studied within the fixed-nuclei approximation. The static potential is determined from near-Hartree-Fock single-center bases set, and the target distortion effects are included up to second-order level only (parameter-free electron polarization potential of Jain and Thompson[1]). The scattered electron function, bound orbitals, and the static potential include terms up to ℓ=6. The final total cross sections (σ_I) are similar to CH_4 (in shape, i.e. flat beyond 1 eV) except that SiH_4 numbers are larger by about a factor of 1.5. The (0→0) transition contributes more than 95% (on an average) to the σ_I. The (0→3) transition is larger than the (0→4) one in the present energy region. The momentum transfer cross section shows a pronounced Ramsauer-Townsend (RT) minimum around 0.3 eV, while the σ_I curve displays a very shallow structure around 0.4 eV.

*Work supported by U.S. Dept. of Energy (OBES).

†Present address: Dept. of Chem., Ohio State Univ., Columbus, Ohio 43210.

1. A. Jain & D.G. Thompson, J. Phys. B 15, L631 (1982).

CA-14 Reactions of He_2^+ and $He(2^3S)$ with N_2, O_2, and CO_2 at Atmospheric Pressures,* J.M. POUVESLE and J. STEVEFELT, GREMI, U. of Orléans, France, and H.JAHANI, V.T. GYLYS and C.B. COLLINS, U. of Texas at Dallas -- Results have been obtained that exploit the large dynamic range and high data acquisition rates that are available from time resolved spectroscopic studies of preionized stripline discharges. The critical importance of termolecular channels for ion molecule reactions was confirmed, the effective reaction rate of He_2^+ with N_2 being increased to a value three times in excess of the Langevin rate at six atmospheres helium pressure, with no evidence of saturation. The termolecular reactions of the neutral metastable species were found to occur at rates around 10^{-31} cm^6 s^{-1} that were in good agreement with a corrected theory of collisionally induced capture.

* Supported in part by NSF Grant ECS.83 146 33 and in part by NATO Grant 655/84.

CA-15 Direct and charge - exchange excitation in collisions of fast ions with neutrals in the sheath of a hollow cathode discharge, F. HOWORKA and I. KUEN, Institut f. Experimentalphysik, Universität Innsbruck, Austria -- Electron impact excitation of atomic and ionic lines is the dominant excitation process in the negative glow of low pressure discharges. In the cathode sheath, however, some ionic states are excited by exoergic or endoergic charge transfer from fast ions. The hollow cathode discharge is ideal to study these phenomena as a simple scan across the discharge gives both regions, glow and sheath, and permits a comparison between the important processes. The present work gives details on the charge exchange, direct ionic and electron impact excitation in rare gas mixtures, where the gas with the higher ionization potential is the majority gas (97%) and stands in the first place: He-Ne, He-Ar, He-Kr, He-Xe, Ne-Ar, Ne-Kr, Ne-Xe, Ar-Kr, Ar-Xe, Kr-Xe.

CA-16 *Modeling of Ion Molecule Reactions at High Pressures, C. D. EBERHARD and C. B. COLLINS, U. of Texas at Dallas and J. STEVEFELT, GREMI, U. of Orleans, France--Recent modeling[1] of ion molecule reactions suggests that the dynamics of the complex formed from the initial encounter of the reactants may control the overall rate at which the products appear. A model of the reaction complex was formulated. Both coherent and incoherent collisional processes of excitation and deexcitation of the complex were included. The overall reaction rates for the charge transfer reactions of He_2^+ with N_2, CO_2, Ne and Ar at atmospheric pressures were predicted.[2] Model parameters were fixed by matching experimentally measured reaction rate coefficients at 300°,[2,3] and the temperature dependences of the termolecular rate coefficients were predicted for these species.

*Supported in part by NSF Grants ECS8314633 and INT 8116436 and in part by CNRS.

1. C. B. Collins, F. W. Lee, W. M. Tepfenhart and J. Stevefelt, J. Chem. Phys. 78, 6079 (1983).
2. F. W. Lee, C. B. Collins, and R. A. Waller, J. Chem. Phys. 65, 1605 (1976).
3. J. M. Pouvesle, A. Bouchoule and J. Stevefelt, J. Chem. Phys. 77, 817 (1982).

CA-17 Synchrotron Studies of Collision Induced Absorption and Emission in I_2 and ICl. D. C. LORENTS, AND R. L. SHARPLESS, SRI International and K. TANG, Western Research Labs --Tunable UV radiation from SSRL has been used to excite the absorption bands of I_2 in Ar and Ar/Xe mixtures over the range of 105-300 nm. Optical emissions at 340, 308, and 250 nm were monitored as a function of buffer gas pressure. Absorption of the I_2 in the 170-220nm range is observed to be strongly dependent on Ar pressure as is the emission intensity at 340 nm which originates from the $I_2(D'-A)$ transition. The dependence of the emission band intensities on excitation energy have been obtained and quantum yields will be reported.
*Work supported by DARPA through ONR.

CA-18 On the Determination of Negative-ion Mobilities in SF_6 from the Pulsed Townsend Technique,* J. de URQUIJO, I. ALVAREZ and C. CISNEROS, Instituto de Física, UNAM, Mexico -- A recent review on the mobilities of SF_6-ions in SF_6 shows a large discrepancy between calculated and measured negative ion mobilities above E/N ≥360 Td[1], the latter being obtained from a simple model considering the formation of a single, stable species. Thus, we have developed a more comprehensive analysis as applicable to the PTT, by considering that several ion-molecule reactions may take place, leading to the formation of SF_5^-, SF_6^- and F^- from the parent $(SF_6)^*$. The usefulness and limitations of the present analysis are discussed in terms of experimental transients in the range 390-600 Td.

*Work partially supported by CONACyT, Grant PCCBBNA 020668.

[1]K.P. Brand and H. Jungblut, J. Chem. Phys. 78, 1999 (1983).

CA-19 Mobilities of the Structural Isomers of $C_2H_xO^+$ (x = 3 to 5) in Helium at 293K, P.W. HARLAND, Chemistry Department, University of Canterbury, New Zealand. --- The mobilities of the structural isomers $C_2H_xO^+$ (x = 3 to 5) produced from dilute mixtures (<0.1% of c-C_2H_4O, CH_3CHO, C_2H_5OH and CH_3OCH_3 in He have been measured for $40 \times 10^{-21} < E/N < 140 \times 10^{-21}$ Vm^2 using a drift tube mass spectrometer with a movable ion source. Differences between the mobilities of structural isomers of the same chemical composition lie in the range 2-6%, the isomers produced from c-C_2H_4O exhibiting lower mobilities than the corresponding linear isomers formed from CH_3CHO, C_2H_5OH and CH_3OCH_3. The mobilities of the $C_2H_xN^+$ (x = 0 to 3) ions were independent of the precursor molecule, C_2N_2, CH_3CN and CH_3NC, within the experimental uncertainty, ± 2%. These observations may be interpreted either in terms of charge delocalisation in the cyano and isocyano ions or the possibility of lower isomerization barriers resulting in the exclusive formation of the lower energy isomer from the He^+ ion charge transfer in the drift tube ion source.

CA-20 Measurement of SF_6 ions with Gerdien Counter, J.P. NOVAK and G. ELLENA, IREQ, Varennes, Québec, Canada -- A quantitative model of the Gerdien counter has been formulated and solved in a two-dimensional approximation. The model takes account of diffusion, flow development in the entry region, and end-effects of the electric field. Comparison of the numerical results with analytical solutions for two particular simplified cases showed good agreement. The ion density and mobility were determined by fitting the calculated ion-current characteristics to the collector-current curves. Best-fit value of the negative-ion mobility is $\mu_n = 0.38$ $cm^2V^{-1}s^{-1}$: the difference between this and the previously reported value of 0.58 $cm^2V^{-1}s^{-1}$ is partially due to the inaccuracy of the formerly used simple single-particle interpretation but is also affected by recalibration of the flow-measuring system. Negative-ion density corresponding to the entry plane of the counter is 3000 cm^{-3}; no measurable difference has been observed for respective values between negative and positive ions. Ions were produced by natural sources in a 110-L (12 in. dia.) Pyrex container.

CB-1 Galton-Watson Models for Townsend Discharge Experiments, D. M. Cap, General Electric Co. LBG -- Stochastic generalizations are presented for the deterministic descriptions normally used in the analysis of Townsend discharge experiments. The models use probability notions and language to describe the growth in space of an electron avalanche and the electron regeneration that occurs at the cathode. They provide alternative methods for estimating the Townsend ionization coefficients, based on measuring the waiting time until breakdown or the total charge collected by the anode when a single progenitor electron is released from the cathode, that can be compared with the results obtained by the classical current multiplication method. Since ionization coefficients are tabulated for many different electrode material and fill gas combinations, the results obtained by applying the extinction and total progeny theorems for Galton-Watson branching processes to Townsend discharges are also useful for computing breakdown probabilities.

CB-2 Decomposition Rates of SF_6 in SF_6/Ne and SF_6/N_2 Corona Discharges,* M. C. SIDDAGANGAPPA, R. J. VAN BRUNT, and A. V. PHELPS, National Bureau of Standards -- The absolute and SF_6-normalized rates of production of SOF_2, SO_2F_2, SOF_4, and SO_2 have been measured for SF_6/Ne and SF_6/N_2 mixtures containing trace levels of O_2 and H_2O in a continuous 40 μA negative corona discharge by the technique previously described[1]. In both mixtures, the total oxyfluoride plus SO_2 yield per mole of SF_6 resulting from reactions of the SF_6 dissociation fragments with oxygen containing contaminants increases with decreasing SF_6 content. This is consistent with a reduction in the competitive recombination rate of the dissociation fragments in the discharge due to the dilution of SF_6 in N_2 and Ne. The results for SF_6/N_2 are compared with theoretical predictions of the maximum SF_6 decomposition rates from numerical solutions of the Boltzmann transport equation used in a model[1] of the discharge.

*Supported in part by U.S. Department of Energy

[1]R. J. Van Brunt, NBS J. Res. 90, 229 (1985).

CB-3 The Recovery of a High Pressure Diffuse Discharge* - R. Piejak, GTE Labs. Inc., Waltham, MA. The hold-off voltage between two uniform field electrodes has been measured as a function of time after a high pressure diffuse discharge in nitrogen and nitrogen/air mixtures with a tripropylamine (TPA) seedant. The hold-off voltage is defined as the highest voltage that the gap can withstand without appreciable current flow. A flashboard located behind an anode mesh electrode creates uv preionization by photo-ionizing the TPA. A high current (600-800amp), short duration (250nsec) diffuse discharge with a cross section of 5 cm^2 is established. At a predetermined time delay after the main discharge, a second pulse is applied to the discharge gap and the hold-off voltage is determined. Background gas pressure of 400 and 500 torr and electrode separation of .42 to .56 cm have been used. Data for the recovery of the hold-off voltage as a function of time after the main discharge under these conditions will be presented. Some comparisons to the recovery of arc discharges will be given. The effect of the TPA on the initial breakdown of the discharge gap will be discussed.

*Supported in part by the Naval Surface Weapons Center.

CB-4 Experimental Study of Laser Triggered Electrical Breakdown in Air, S. YOSHIDA, S. KUBODERA, R. OZAKI, T.SAKAI and T.UCHIYAMA, Keio U.--As a preliminary study of laser triggered long distance air breakdown, an electrical breakdown in atmospheric air has been optically triggered using a pulsed CO_2 laser and a Marx generator. The purpose of the present work is to estimate the effective continuance time of the laser induced plasma. Here the continuance time is defined as the existence time of the plasma whose number is sufficient to initiate a breakdown. For that purpose, the Marx generator is switched by the laser after delay time which can be externally controlled in the range of 0-10 ms. Thus the effective continuance time was measured as a function of the applied voltage. In many cases, the maximum continuance time was in the order of milisecond and the breakdown streamer was seen to be directed by the optical breakdown spark bead produced by a focused laser pulse. These results indicate that kilohertz radiation of the CO_2 laser may supply continuous plasma which is sufficient in number to trigger the breakdown of the present length. This implies that it may be possible to trigger a very long distance breakdown by scanning the laser which supplies the continuous plasma.

CB-5 A Pressure Study of Long-Pulsed, Electron-Beam Generated Helium Plasmas, L. W. Downes, S. D. Marcum and W. E. Wells, Miami University. We have reported[1] a previously unobserved emission at 431 nm in a helium plasma that was excited by a long-pulsed, electron-beam discharge (250 kV, 200 A, 900 ns pulse length) at 1000 Torr. This emission was shown to have an excitation pulse length dependence. The emission band at 431 nm clearly has a Q-branch and an R-branch giving a rotational constant, B_e= 9.1 cm^{-1}, compatible with a helium specie emission. This study has been extended over a pressure range of 5 to 5000 Torr. The data has shown two mechanisms dependencies that occur in the plasma. At low pressures an inverse pressure dependence is dominant and at high pressures the dependence is linear. The two mechanisms appear to be equal between 1200 and 2000 Torr. Studies have shown a band absorption that correlates with the 431 nm emission but the peak absorption occurs at 450 nm. These emission and absorption characteristics will be presented and gas purification techniques will be discussed.

1. Downes, Marcum and Wells, Bull. Am. Phys. Soc. 30, 146(1985), (37th GEC).

CB-6 Ionization Equilibrium in a Debye-Hückel Plasma, S.R. Spielman* and P.A. Vicharelli, GTE Laboratories, Inc., Waltham, MA -- Results of quantum-statistical calculations of the equilibrium properties of a partially ionized Debye-Hückel plasma are presented. The input data consist of analytic energy levels[1] and phase shifts,[2] and the results, in the form of second virial coefficients, are tabulated for PVT conditions that satisfy the Frank-Thompson and electron degeneracy criteria.[3] The plasma is treated as a nonideal binary mixture of electrons and positive ions that may recombine to form neutral atoms under conditions that are consistent with a modified Saha equation. Since the binding energies entering the Saha equation are functions of temperature and electron density, an iterative approach is employed until self-consistency is achieved.

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1. A.E.S. Green, Phys. Rev. A26, 1759 (1982).
2. A.E.S. Green, et al, Int. J. Quan. Chem. 16,331 (1982)
3. A.B. Cambel, et al, "Real Gases", Academic Press, 1963.

CB-7 Electron transport and rate coefficients near boundaries, L.C. Pitchford, GTE Labs, Waltham, MA; P. Segur and M. Yousfi, Univ. Paul Sabatier, Toulouse, France; and T.J. Moratz, Univ. of Pittsburgh, Pittsburgh, PA -- Electron transport and rate coefficients are well parameterized by E/n, the reduced field strength, when the electrons have lost memory of their initial conditions and if the fields are varying slowly in space and time. We have extended our previous studies of "field nonequilibrium" electron transport to the consideration of boundary effects. Spatially dependent electron velocity distribution functions have been calculated from the Boltzmann equation for electrons in D_2 over a range of E/n from 200 to 28,200 Td and for pd products on the order of 1 cm Torr. These calculations assume isotropic scattering. A field equilibrium region is not reached for E/n greater than 2260 Td at these pd values. The parameters chosen for these calculations are appropriate to the experiment of Jelenkovic and Phelps.[1]

1. B.M. Jelenkovic and A.V. Phelps, 4th International Swarm Seminar, Tahoe City, CA, 1985.

CB-8 Plasma-Sheath Structure for an Electrode Contacting an Isothermal Plasma: I. Formulation and Quasi-neutral Solution,* S.A. SELF and L.D. ESKIN, Mech. Engr. Dept., Stanford Univ. --The plasma-sheath transition between a plane electrode and a semi-infinite, weakly ionized, isothermal plasma, maintained as a balance between electron impact ionization and three-body recombination, is examined in terms of the continuum equations for electrons and ions, together with Poisson's equation. Arbitrary levels of current density, and of electron and/or ion emission at the electrode are allowed. The problem is formulated as a set of five coupled nonlinear first order differential equations which are to be solved numerically as a two-point boundary value problem. Also, an analytic solution in the quasi-neutral approximation is given. This reveals the existence of a critical current density at which the anode potential fall inverts from negative to positive, and also predicts the existence of maximum current densities that can be drawn to a cathode and to an anode without electron or ion emission respectively.

*Work supported by the AFOSR, Grant No. 83-0108.

CB-9 Plasma-Sheath Structure for an Electrode Contacting an Isothermal Plasma: II. An Electrically Isolated (Floating) Electrode,* L.D. ESKIN and S.A. SELF, Mech. Engr. Dept., Stanford Univ. --The coupled system of five first order ordinary differential equations developed in Part I is solved numerically for an electrically isolated (floating) electrode ($\bar{J} = 0$) . This two-point boundary value problem is solved using the method of quasilinearization with superposition and orthonormalization. The quasi-neutral solution developed in Part I is used to provide far-field boundary conditions. Electron emission by the electrode is considered by allowing a non-zero value for the electron number density at the electrode surface. The solution is found to be quite sensitive to the magnitude of the emitted electron flux. Sufficient electron emission is shown to create a potential minimum, i.e., a virtual cathode, and causes the electrode potential to rise to the plasma potential.

*Work supported by the Air Force Office of Scientific Research, Grant No. 83-0108.

CB-10 On the Sheath Potential in RF-Discharges - K.-U. RIEMANN, Ruhr-Universität Bochum, FRG. Starting from a previous theory of the plasma sheath transition in a stationary, weakly ionized plasma (charge exchange model [1]), we calculate the plasma potential, sheatn voltage and ion current to the wall (electrode) Under quasistationary conditions - i.e. for frequencies below the plasma frequency - this theory can be generalized to describe the plasma potential and sheath voltage in a RF-discharge.

[1] K.-U. Riemann, Phys.Fluids 24, 2163 (1981)

CB-11 DOPPLER BROADENED LINE SHAPES OF ATOMIC HYDROGEN IN A PARALLEL PLATE RADIO FREQUENCY DISCHARGE, Anthony L. Cappelli [1], Richard A. Gottscho, and Terry A. Miller [2], AT&T Bell Laboratories, Murray Hill, NJ 07974. Doppler shifted atomic hydrogen emission (Balmer α) is observed from a low frequency, rf discharge through molecular hydrogen by collecting the light through a hole in one of the electrodes. Doppler shifts as large as 0.7 nm, corresponding to an energy of 540 eV or 85% of the peak applied voltage, are observed during the cathodic part of the rf cycle when ions are accelerated by the sheath electric field. The mechanisms for hot atom production are discussed in terms of both gas-phase and surface ion-impact phenomena. Most of the hot atoms are produced via gas-phase ion-atom and ion-molecule collisions, although a substantial number are created as a result of simultaneous neutralization and reflection of ions at the electrode surface and/or by sputtering of adsorbed hydrogen. As much as 30% of the atomic hydrogen emission is substantially Doppler shifted, indicating that most of the atomic emission in the sheaths is actually produced by ion-impact and not by electron-impact.

[1] Summer student, current address: 600 U Street N. W. Washington, D. C.

[2] Current address: Chemistry Department, Ohio State University, Columbus, OH.

CB-12 Cathode Plasma Behavior in Long Pulse, Broad Area Electron Beam Diodes.*
R.E. SHEFER, R. KLINKOWSTEIN, J. JACOB, M. TEKULA, SCIENCE RESEARCH LABORATORY, INC.--
Cold cathodes, used extensively in high curren relativistic electron beam diodes, are limited in pulse duration by the diode impedance collapse caused by the motion of the cathode plasma front across the cathode-anode gap. In this paper, we describe the temporal evolution of the cathode plasma and the conditions necessary for the formation of a stable, stationary plasma boundary. A novel method is investigated for confining the plasma and controlling the shape of the plasma meniscus. Applications to cathodes capable of providing microsecond duration, broad area electron beams with current densities of 10-50 Amps/cm^2 are discussed.
*Work supported by DARPA/Air Force Aeronautica Systems Division under contract F33615-84-C-2487.

CB-13 Axial Electric Field in a Ne-Ar Gas Mixture Capillary Tube Discharge Positive Column Plasma *T. KANEDA, *T. KUBOTA and +J.S. CHANG *Tokyo Denki Univ., Japan, + McMaster Univ., Canada - The noble gas mixture capillary tube discharge positive column plasma is often used in a plasma display system and gaseous lasers. In this work, the axial electric field in a Ne-Ar gas mixture narrow tube discharge positive column plasma has been studied both experimentally and theoretically. The tube diameter of 0.5 and 0.8 mm DC discharge tube was used in the present investigation together with movable anode for axial electric field measurements, and optical emission from plasma was taken. The electron energy conservation and the charged particle transport equations was used to determine the axial electric field and electron temperatures for Ne-Ar gas mixtures. The results show that: (1) the axial electric field/pressure, E_Z/p, decreases with decreasing (pressure X tube radius), pR; (2) E_z/p decreases slightly with increasing gas discharge currents; (3) theoretically predected E_Z/p agree well with present experimental results; (4) no significant extra tube effect on E_Z/p was observed from both experimental and theoretical results, if we analyzed results in term of pR.

CB-14 **Electrical and Spectroscopic Characterization of a Linear Thyratron**, **R.A. Petr, C.H. Fisher, J. Demboski, and M.J. Kushner, Spectra Technology, Inc. (Formerly Mathematical Sciences NW)** **—A linear thyratron utilizing a 10-cm long dispenser cathode has been electrically and spectroscopically characterized using a pulsed hook method interferometer. The thyratron has been operated with a peak current of 5 kA, $dI/dt=10^{11}$ /s and cathode current density of >150 A/cm^2. Uniform cathode coverage has been obtained by using a DC simmer current and, confirmed by framing camera photography and by observing plasma emission from opposite ends of the cathode. Hook method spectroscopy was used to obtain time and spatially resolved maps of absolute excited state densities (resolution 5 ns, 0.5 mm). Current constriction was observed near the control grid slot. A maximum He 2^3P density of 6×10^{12}/cm^3 was observed near the slot at a local current density of ≈1 kA/cm^2.**

***Work supported by AFSC Contract F33615-84-C-2474**

CB-15 Spectroscopic Detection of Gas Phase SiH_x Species. JODA C. WORMHOUDT and ALAN C. STANTON, Aerodyne Research, Inc. - Techniques for detection of SiH_x species are important as diagnostic tools in the study of deposition processes. In our experiments aimed at development of such techniques, SiH_x species are produced either by thermal decomposition of Si_2H_6 or by reaction of SiH_4 with fluorine atoms. The SiH and SiH_3 radicals are detected by infrared tunable diode laser absorption near 2000 cm^{-1} and, for SiH_3, in the 800-900 cm^{-1} region. This technique may be adapted to quantitative measurements. Results of the high resolution IR measurements of SiH and SiH_3, including measured line positions and estimates of absorption line strengths, are presented. Comparisons are made with previous observations in silane plasmas, and a discussion of applications of the techniques to measurements in deposition reactors is presented.

CB-16 Pulse Measurement of the Electron Energy Distribution in a Noisy Plasma, V.A. GODYAK, GTE Lighting Products, Danvers --An electronic circuit for pulse probe measurement of electron energy distribution, EED, with noise supression has been designed and implemented for a Neon-Mercury d.c. discharge. Discharge parameters were pR=2.5 Torr cm, a Mercury pressure of a few mTorr and a discharge current of 0.1-1A. The comparison of EED and mean electron energy obtained in this experiment and those obtained by the conventional method using probe voltage modulation with a small r.f. signal revealed a significant difference. This difference was due to a change in the probe work-function. This occurs because of probe heating during the relatively long measurement time using the conventional method. Using a plasma noise supression circuit with a second reference probe in combination with pulse measurement (τ=0.5ms) permitted us to obtain a nondistorted EED in a noisy rare gas-Mercury discharge with high resolution and dynamic range.

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CB-17 A Theory of the Electrode Sheath in a RF Discharge, V.A. GODYAK, GTE Lighting Products, Danvers --The self-consistent set of equations describing the dynamic and time-averaged characteristics of the electrode sheath in a capacitive r.f. discharge has been derived from Poisson, ion momentum transfer, r.f. current continuity and time averaged charge conservation equations. It is shown that the obtained set of equations completely determine the behavior of the r.f. sheath parameters through two universal dimensionless parameters: $\beta=a/D$ and $\alpha=\lambda/D$ (a and D are the amplitude of electron oscillation and electron Debye radius at the plasma boundary, respectively, and λ is ion mean free path). In the case of a collisionless sheath ($\alpha>>1$), an analytical solution has been found. The calculated capacitance and d.c. voltage of the electrode sheath were in good agreement with previously published experimental data obtained in low pressure Mercury r.f. discharges.

CB-18 The Spatial and Temporal Evolution of the Glow in a RF Discharge,* G. A. HEBNER and J. T. VERDEYEN, University of Illinois at Urbana-Champaign--The temporal and spatial evolution of the glow of a 1.0 MHZ and 2.6 MHz RF Helium discharge has been photographed with a high speed framing camera. The use of the framing camera allows one to observe the effect of bias, power, and pressure on the entire plasma. Spectral selectivity is obtained by using an interference filter for some photographs. Evidence is presented of electrons with a ballistic behavior in the body of the glow and a time delay between the maximum optical intensity of the glow and the maximum RF voltage. The effect of the DC self bias on the glow is also shown. The implications of these observations on the dynamics of the ion motion in the plasma will be discussed.

*Work supported by ARO (DAAG-29-83-K-0108) and Air Force Aero Propulsion Laboratory (F33615-83-K-2335).

CC-1 Emission and Absorption Characteristics of the Transition Region of a Thermally Generated Heat Pipe - D. G. Hild and W. E. Wells, Miami University, Oxford, Ohio 45056. - The emission and absorption characteristics of a sodium heat pipe, integrated along its axis, have been presented[1]. This study showed significant emission from the diatomic triplet molecule at 400 to 450 nm and 550 to 580 nm. An absorption window was observed at near zero loss in the 400 to 450 nm range. A significantly more absorptive window was observed for the 550 to 580 nm range. The emission and absorption characteristics were studied by differential optical spectroscopy along the axis of the transition region of thermally generated heat pipe operating between 1600 K and room temperature. An argon buffer pressure was maintained at 100 Torr. Of particular interest were the triplet emissions at 400 to 450 nm and 500 to 580 nm. Both of these emissions have displayed gain near the condensation region of the heat pipe. Model characteristics for this plasma will be presented.

1. Petricevic, Downes, Hild, Marcum, Mihailidi, Stetser and Wells, Bul. Am. Phys. Soc. 30, 146(1985), (37th GEC).

CC-2 Transport of Cu and CuCl in a Double-Pulsed CuCl Laser,* R.J. NIEFER, J.B. ATKINSON and L. KRAUSE, Dept. of Physics, University of Windsor, Ontario, Canada -- A copper-vapor laser, operated in a double-pulsed Cu/CuCl discharge, frequently suffers from a deterioration of output energy, due at least in part to the degradation and transport of the lasing medium, and to chemical reactions involving Cu and CuCl and resulting in the formation of other compounds. These processes have been investigated in a laser discharge in which the electrodes are contained entirely within the hot-zone of the discharge, unlike in previous devices with which appropriate comparisons are drawn.

*Research supported by the Canadian Department of National Defence.

CC-3 Internal Attenuation of Laser Radiation in the CuCl Laser,* R.J. NIEFER, J.B. ATKINSON and L. KRAUSE, Dept. of Physics, University of Windsor, Canada -- A double-pulsed neutral copper vapor laser, based on a Cu/CuCl discharge, was placed in tandem with a $ZnCl_2$ discharge cell, in a common optical cavity. The $ZnCl_2$ in the separately heated discharge tube acted as a source of Cl-based plasma by-products which are also likely constituents of the Cu/CuCl laser plasma. The timing of the two discharges was varied relative to one another and the Cu laser emission at λ = 510 nm and λ = 578 nm was investigated to test the optical absorption losses in the combined cavity in relation to time. The experiments provide some insight into the chemical effects in the laser plasma, that may limit the energy output of a Cu/CuCl laser.

*Research supported by the Canadian Department of National Defence.

CC-4 Electron Beam Induced U. V. Lasing at Atmospheric Pressures, W. L. ATCHISON, USAF Academy, U. of California Davis and LLNL -- The ultra violet yields from the N_2 triplet states caused by an REB have been calculated for pressures from 0.5 to 1000 torr. These calculations indicate that the charge particle beam and U. V. pulse propagate concurrently at or near the speed of light, several of the mechanisms that shut down the 3371Å lasing are avoided. The results predict a yield at pressures above 100 torr due to collisional activation from the electron cascade caused by the beam electron. Preliminary data taken on the LLNL Experimental Test Accelerator indicate enhancement of the 3371Å line by greater than 10^3 at a pressure 1 atmosphere.

CC-5 Prompt and Delayed Photolysis of Cs_2 Excited at Blue Wavelengths,* F. DAVANLOO and C. B. COLLINS, U. of Texas at Dallas--In this work a time-delayed, double resonance technique[1] was used for the state selective photolysis of Cs_2 with particular attention being placed on the production of the fine structure components of the 5^2D and 6^2P states of cesium. A quantitative model was constructed to fit the data obtained at seven wavelengths of photolysis over the blue region of the visible spectrum. Some delayed processes tending to attenuate the product state selectivity were found and characterized. A delayed source for the production of $Cs(5^2D_{5/2})$ atoms was observed to have a lifetime <100 nsec while another distinct and short lived delayed source contributed to the production of $Cs(6^2P)$ atoms. Both delayed sources were tentatively identified as molecular states correlated with either $Cs(7^2s)$ or $Cs(5^2D)$.

*Supported by NSF Grant PHY8214273.

1. F. Davanloo, C. B. Collins, A. S. Inamdar, N. Y. Mehendale and A. S. Naqvi, J. Chem. Phys. 82, 4965 (1985).

CC-6 Very Short Laser Pulses and the Two-Level Atom: Is Detuning Relevant?,* P.L. DE VRIES and J.F. SCIPIONE, Miami University, Oxford, OH--Recent advances in laser technology has led to the demonstration of laser pulses as short as 12 femtoseconds in duration. The existence of such short pulses mandate a reexamination of some of our basic notions concerning the interaction of radiation with matter. We have recently investigated the standard solution of the two-level atom in an intense, nonresonant radiation field, in the short time limit. The counter-intuitive conclusion is that for very short laser pulses the detuning is not of particular importance.

*Work supported in part by the National Science Foundation under grant number PHY-85-06679. Achnowledgment is also made to the Donors of the Petroleum Research Fund, administered by the American Chemical Society, for partial support of this research.

CC-7 Electron Production by Photoionization of CS_2 and SO_2 at 193 nm,* L.C. LEE and W.C. WANG, San Diego State University,--Electrons produced by photoionization of CS_2 and SO_2 are investigated using a parallel-plate drift-tube apparatus. The number of electrons were measured by the transient current induced by electron motion between the electrodes. The dependence of electron current on electron density as function of gas pressure and laser power was investigated. At low charge density, the electron current is proportional to the product of gas pressure and square of laser power, indicating that electrons are produced by a two-photon-ionization process. The measured TPI coefficients are 3.3×10^{-27} and 8.3×10^{-30} for CS_2 and SO_2, respectively. At high charge density, the electron current is greatly affected by the space charge. The electric field induced by space charge will reduce the total electric field in the plasma region such that the charge recombination rate increases. The probability for electron leakage from a high-charge-density plasma will be discussed.

*Work supported by Air Force Office of Scientific Research under Grant No. AFOSR-82-0314.

CC-8 Laser Multiphoton Ionization of Benzene, M.N. Spencer, J.S. Dickinson, D.J. Eckstrom, S R I International--At 248 nm benzene undergoes efficient two-photon ionization. Preliminary experiments at low fluence by Bischel et al [1] established absolute cross sections for this process. Subsequent mass spectrometric experiments by Rossi and Eckstrom [2] suggest that at higher laser intensities the ionization yield is substantially lower than what one would expect on the basis of a three-level kinetic model using Bischel's cross sections. We have made quantitative measurements of the photoionization yield at high fluence and in the presence of buffer gases by using the microwave cavity technique to determine electron densities following excimer laser ionization. In addition to studying pure benzene at low pressure, we also measured the ionization yield of benzene seeded in helium. We will report the effects of high laser intensities and of buffer gases on the photoionization yields.

1 W.K. Bischel, L.E. Jusinski, M.N. Spencer and D.J. Eckstrom, J. Opt. Soc. Am. B 2, 877 (1985).
2 M. Rossi and D.J. Eckstrom (submitted for publication).

CC-9 Recycling of Optical Radiation by Xe Flashlamps,* C. E. UHRICH, K. S. JANCAITIS, and H. T. POWELL, Lawrence Livermore National Laboratory -- We have measured the reemission efficiency of pulsed Xe flashlamps for absorbed optical radiation by comparing the output of clear-fused-quartz lamps with and without reflective, multilayer, dielectric coatings. Absorbed optical power at wavelengths from 250 to 400 nm appears to be equivalent to an equal increase of electrical input. Measurements are underway to measure the recycling efficiency of radiation at other wavelengths.

*Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48.

CC-10 Dependence of Xe Flashlamp Emission on Bore Diameter and Input Power,* K. S. JANCAITIS, A. C. ERLANDSON, and H. T. POWELL, Lawrence Livermore National Laboratory -- We have studied the emission spectra of pulsed Xe flashlamps from 0.55 to 4.2 cm in bore diameter over a range of pulsewidths (100-500μs FWHM) and electrical power loadings (5-100 kW/cm^2). After the arc is fully established, the emission spectra in all cases are nearly identical at equal power per unit wall area rather than power per unit volume. Analysis of lamp emissivities helps explain this result.

*Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48.

CC-11 Effect of Preionization on Xe Flashlamp Performance,* A. C. ERLANDSON, C. E. THOMPSON, and H. T. POWELL, Lawrence Livermore National Laboratory -- We have measured the broadband radiant efficiencies and detailed emission spectra of pulsed Xe flashlamps, with and without the application of preionization pulses. We studied flashlamps with bore diameters from 0.55 to 4.2 cm, using FWHM pulsewidths from 100 to 500μs. Lamp spectra taken during the arc expansion phase show emission from wall-ablated species and Xe-ions which does not appear after the arc is fully established. These features are greatly reduced by the application of a preionization pulse several hundred microseconds before the main pulse. Preionization improves overall lamp radiant efficiency, especially for the shorter pulsewidths.

*Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48.

CC-12 Experiment and Theory in Continuous Xe Arcs at Moderate Currents. P.J. WALSH and AHMAD KERMANI, Fairleigh Dickinson Univ. and Peak Systems - - Radiant output, heat conduction loss and voltage have been measured in di=0.7 cm quartz lamps, with sturdy thoriated tungsten electrodes, at currents I=25 to 80 amps, fill pressures p=0.5 to 3 atm abs. and electrode spacings s=11 to 20 cm. For these arcs, the arc drop was fitted by $V=AsI^{b}p^{c}/d$. In units above A, b and c have deviations: ± 0.1, ± 0.03 and ± 0.05. In a uniform, electron-atom collision plasma, controlled by radiative recombination, we derived V as above and $T=0.51d^{u}I^{v}p^{w}$ for electron temperature. With our parameters, u= -0.16, v=0.08, w= -.02 and T=0.56-0.88 ev. Derived A, b and c are compared with experiment and theory below. Conduction loss is large in our arcs, 30% to 45% of input power, and must be included in further analysis.

Our Expt/mod I/contin	A=1.74	b=0.40	c=0.29
J.H. Gonçz/high I/pulsed	1.28	0.5	----
P.J. Walsh et al. Black ion-atom plasma	0.91	0.45	0.00
Theor. of Elec-atom/rad recomb	1.29	0.47	0.62

SESSION DA

08:00, Wednesday, October 16

ELECTRON-MOLECULE COLLISIONS: ATTACHMENT

Chairperson: M. Dillon
Argonne Nat'l Lab

DA-1 Measurement of Cross Sections for the Production of Negative and Positive Ions by Electron Impact on $HC\ell$, H_2O, CO, CO_2, NH_3, CH_4, and SiH_4*, S. K. Srivastava and O. J. Orient, Jet Propulsion Laboratory/California Institute of Technology--Recently, we have completed measurements on the dissociative electron attachment cross sections for $HC\ell$, CH_4 and SiH_4 and dissociative ionization cross sections for H_2O, CO, CO_2, NH_3, CH_4 and SiH_4. A crossed electron beam-molecule beam collision geometry was employed for this purpose. Normalized values of cross sections were obtained by the relative flow technique.[1] The background pressure in all measurements was of the order of 1.0×10^{-7} Torr. We find that, except for H_2O, the present results are in agreement with some previously published data. Our results are also compared with the predictions of some theoretical calculations. The details on the various experimental procedures and comparisons with previous results will be given at the time of presentation.

*The work described here was carried out at the Jet Propulsion Laboratory, California Institute of Technology and was sponsored by AFOSR and NASA.

1. O. J. Orient and S. K. Srivastava, J. Chem. Phys. 78, 2949 (1983).

DA-2 Dissociative Electron Attachment to SO_2,* S. M. SPYROU, I. SAUERS, and L. G. CHRISTOPHOROU, Oak Ridge National Laboratory--The total rate constant $k_a(\langle \varepsilon \rangle, T)$ for dissociative electron attachment to SO_2 has been measured as a function of the mean electron energy $\langle \varepsilon \rangle$ (1.9 to 4.8 eV) and temperature T (300 to 700 K) using the electron swarm technique. From the measured $k_a(\langle \varepsilon \rangle, T)$ the total attachment cross sections $\sigma_{da}(\varepsilon, T)$ were determined. The peak value (at $\sim$4.5 eV) of σ_{da} increases by more than a factor of two when T is increased from 300 to 700 K, but the peak position and onset of σ_{da} shift to lower energy only slightly, indicating a vertical onset dissociative attachment process. The magnitude of $\sigma_{da}(\varepsilon, T \simeq 300\ K)$ was also determined mass spectrometrically. These measurements resolve the existing disparity in the literature[1] concerning the magnitude of $\sigma_{da}(\varepsilon)$ for this molecule.

*Work sponsored by OHER, USDOE, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

[1]L. G. Christophorou, D. L. McCorkle, and A. A. Christodoulides, in Electron-Molecule Interactions and Their Applications (L. G. Christophorou, Ed.), Vol. 1, Chapt. 6, Academic, New York, 1984.

DA-3 Dissociative Attachment in Vinyl and Allyl Chloride,* P.D. BURROW and K.L. STRICKLETT, U. of Ne, Lincoln--The dissociative attachment (DA) process in vinyl chloride takes place at energies where the $^2\Pi$ state of $C_2H_3Cl^-$ is formed. From symmetry considerations, DA cannot take place through this resonance if the molecule remains planar.[1] The required coupling between $^2\Pi$ and $^2\Sigma$ anion states could arise from attachment to out-of-plane vibrational levels of the neutral or through the incipient out-of-plane distortion of the $^2\Pi$ anion suggested[2] recently. To determine the sensitivity of the cross section to Cl orientation, we examined allyl chloride in which the Cl is out-of-plane but still close to the CC double bond. We find that the cross section is enhanced by a factor of 6.3 over that of vinyl chloride.

*Supported by NSF.

[1]D.D. Clarke and C.A. Coulson, J. Chem. Soc. (A) 1969 169.
[2]P.D. Burrow, A. Modelli, N.S. Chiu and K.D. Jordan, Chem. Phys. Letters 82, 270 (1981).

DA-4 Electron Scattering from Laser-pumped SF_6,* K.L. STRICKLETT and P.D. BURROW, U. of NE, Lincoln--We have examined the changes in the total electron scattering cross section of SF_6 when pumped by a CO_2 laser. The experiment utilizes an electron transmission[1] apparatus and a free molecular jet, rather than the usual static gas cell. The jet is crossed with the laser light at right angles to both the jet and the magnetically collimated electron beam. The laser beam is chopped and the change in the transmitted current is detected synchronously. We observe both increases and decreases in the cross section as a function of electron impact energy. These effects take place at the energies at which temporary negative ion states of SF_6 are known to be formed.[2]

*Supported by NSF.

[1]L. Sanche and G.J. Schulz, Phys. Rev. A 5, 1672 (1972).

[2]R.E. Kennerly, R.A. Bonham and M. McMillan, J. Chem. Phys. 70, 2039 (1979).

DA-5 ATTACHMENT PROPERTIES OF VIBRATIONALLY AND ELECTRONICALLY EXCITED GASES. M. J. Rossi, H. H. Helm, and D. C. Lorents, Chemical Physics Laboratory, SRI International, Menlo Park, CA 94025

Highly vibrationally excited species were prepared by UV photoelimination of appropriate precursors in a parallel plate gap of a Gruenberg-type drift cell. The photoenhanced electron attachment of $CH_2{=}CCl_2$ and $CH_2{=}CF_2$ on 193 nm excitation was studied, and it was concluded that the effect was due to the presence of vibrationally excited HCl and HF. Also, results on a two-laser experiment will be reported where the generation of the excited species and the onset of the electron attachment are separated by a variable delay. Results on electronically excited acetone, CH_3COCH_3 and 1,4-benzoquinone will also be reported. In these cases, the lowest triplet state is generated and its attachment behavior investigated.

*This work was supported by the Physics Program of the Army Research Office.

DA-6 Monte Carlo Calculations on the Relaxation of Initial Secondary Electrons in Electron Beam Sustained Discharges Containing Attachers,* G. F. Reinking, G. Schaefer, and K. H. Schoenbach, Texas Tech University, Lubbock, Texas 79409--Electron beam sustained discharges can be used as fast opening switches. Attachers have to be used to achieve fast opening. To achieve low losses during conduction the discharge has to operate at low values of E/N with an electron energy distribution peaking below 1 eV and, the attachers have to have a cross section above this energy range. For an electron beam sustained discharge the energy of the initial secondary electrons may be well above the energy of the attachment cross section. These initial secondary electrons will subsequently during their relaxation move through the energy range where attachment may occur. Monte Carlo calculations on the relaxation of fast electrons have been performed. In atmospheric N_2 the relaxation time is found to be approximately 0.2 ns. This time is almost exclusively spent in the energy range between 3.5 and 7.5 eV where N_2 has no strong inelastic cross sections. The influence of different attachers such as N_2O and SO_2 is discussed.

SESSION DB

08:00, Wednesday, October 16, 1985

HIGH PRESSURE ARC LAMPS

Chairperson: J. Maya
GTE Lighting Products

DB-1 Arc Models and Diagnostics of the High Pressure Mercury Arc, R.P. Gilliard, General Electric Lighting Business Group and J.T. Dakin, General Electric Corporate Research and Development--Fundamental comparisons are made between calculations of high pressure mercury arc properties and high resolution spectroscopic measurements of a one-dimensional horizontal rotating arc. Rotation of the arc about its axis helps to ensure cylindrical symmetry and axial homogeneity, thereby making determination of input parameters for arc model calculations (e.g., power per unit length and mercury density per unit length) more certain in a diagnosed portion of the arc. In addition to comparisons between theory and experiment, consistency of arc temperature profiles as determined using optically thin line ratios and the Bartel's method will be presented.

DB-2 The Influence of Xenon on the Na-D Maxima in High pressure Sodium Arcs, M.J. JONGERIUS, PHILIPS Research Labs., Eindhoven-- The shifts of the Na self-reversal maxima are often used to determine the sodium and mercury pressure in the high pressure Na-Hg arc[1,2]. Recently, xenon gas is added to improve the luminous efficacy. We measured the Na-D emission lines at arc conditions for which broadening by xenon is dominant. From these results, we calculate that the influence of xenon on the shifts in standard arcs cannot be neglected. A xenon pressure of 4 bar may lead to an overestimate by 20% and 50% of the sodium and mercury pressures, respectively. We propose a correction for xenon and also introduce a new experimental method to determine the xenon pressure.

1. J.J. de Groot and J.A.J.M. van Vliet, 2th int.symp. on incoherent light sources, Enschede, pag. 30 (1972).
2. P.A. Reiser and E.F. Wyner, J. Appl. Phys. 57, 623 (1985).

DB-3 Negative Laser-induced Fluorescence in High-pressure Sodium Arcs, M.J. JONGERIUS and A.J.M.J. RAS, PHILIPS Research Labs., Eindhoven--Laser-induced fluorescence can be used to determine local densities of plasma components in high pressure arcs.[1] Generally the fluorescence signal has a positive sign. However, we discovered that the fluorescence can also become negative if low chopper frequencies of the laser beam are used ($f < 100$ Hz). The amplitude and sign of the signal depend strongly on the relative positions of the detection volume and the laser beam. At higher values of f the negative sign disappears. We present a qualitative explanation for the phenomenon, wherein we assume a laser-induced distortion of the conduction channel of the arc.

1. W.J. van den Hoek and J.A. Visser, J. Phys. D14, 1613 (1981).

DB-4 Spectroscopic Measurements of Pulsed High Pressure Sodium Discharge, N. BRATES, E.F. WYNER, GTE Sylvania Lighting Center, Danvers, MA -- Time resolved spectral power distributions were recorded for a high pressure sodium lamp operated under pulsed conditions (100W average power, 3kW peak power, 180μs pulse width). The visible radiation efficiency as well as lumens efficacy were calculated for different moments into the pulse. A substantial increase of the radiation in the blue region of the spectrum due to mercury and higher sodium energy levels was observed[1]. During the first 10-20μs of the current pulse, the energy is being stored as thermal energy with almost no radiative output: the radiation output increases only 4 times for an almost 30 times increase of the instantaneous power. The color temperature reflects the increase of the blue radiation emission, staying above 3300K throughout the current pulse (compared to 2000K for AC operation).

1. P.D. Jonnson and T.H. Rautenberg, J. Appl. Phys., 50, 3207 (1979).

DB-5 Intensity of Self-Reversed Emission Lines, P.A. Vicharelli, GTE Laboratories, Inc., Waltham, MA -- A simple one-parameter model for the intensity of self-reversed lines emitted from an inhomogeneous plasma is proposed. The basis for the model is a reduced source function constructed from a weighted average of a spatially uniform term and a monotonically decreasing inhomogeneous contribution that vanishes at the boundaries. The uniform term is characterized by a parameter that is fixed by matching with an asymptotic expansion of the emission profile in the limit of large optical thickness. The weight of the inhomogeneous term is found by requiring that the first moment of the reduced source function be normalized to unity. When a highly peaked source function is used, the model approaches one of the limits of the Bartels theory.[1] These results are applicable to all optical thicknesses and may be used to extract information from the intensity at the maxima as well as the minimum of self-reversed lines.

1. H. Bartels, Z. Phys. 127, 243 (1950); 128, 546 (1950).

DB-6 The Wavelength Dependence of the Absorption Coefficient for the Sodium Resonance Line as Measured by Laser Absorption in a High Pressure Sodium Arc - A.K. BHATTACHARYA, T. P. BENSON, and A. BAKER, General Electric Company, Cleveland, Ohio - The absorption of a pulsed dye laser beam by a high pressure sodium arc was measured as a function of wavelength in the vicinity of the sodium 589 nm resonance transition. For a given wavelength the absorption coefficient $k(\lambda)$ was calculated from the degree of absorption and an independent measure of the Na density. The dependence of the absorption coefficient upon distance from line center ($k(\lambda) \sim (1/\Delta\lambda)^n$) cannot be fully explained by a Lorentzian profile ($n = 2$) and will be discussed in terms of other line broadening mechanisms.

DB-7 Measurement of the Sodium Density in a High Pressure Sodium Arc and the Na 514 nm Transition Probability - T.P. BENSON and A.K. BHATTACHARYA, General Electric Company, Cleveland, Ohio - Spatially resolved arc temperatures and sodium density measurements will be presented for a high pressure sodium arc. Absolute intensities of the optically thick 818/819 nm lines were used to determine the arc temperature while the radial profile of the optically thin 514 nm line was Abel-inverted to determine the Na density. Agreement between the measured sodium density and that determined by measured reservoir temperatures and the Na vapor pressure consistently required a value for the Na 514 nm transition probability 2-3 times smaller than the literature value ($A = .011\ 10^8\ sec^{-1}$) of Wiese et al. This modification enables more accurate calculation of the Na density in metal halide arcs of lower Na pressure.

SESSION EA

10:00, Wednesday, October 16, 1985

ION-MOLECULE REACTIONS

Chairperson: R. Johnsen
U. of Pittsburgh

EA-1 The Nature of the $O_2^+ + CH_4 \rightarrow CH_3O_2^+ + H$ Product Ion, J. M. VAN DOREN, S. E. BARLOW, V. M. BIERBAUM, C. H. DePUY, I. DOTAN*# and E. E. FERGUSON*, Chemistry Dept., U. of Colorado--The reaction between O_2^+ and CH_4 to produce $CH_3O_2^+ + H$ has been studied in greater detail than any other ion-molecule reaction. The rate constant is known from 20 to 560K, and independently as a function of KE from thermal (at 80K) to 1eV. The dependence on vibrational and rotational state of the O_2^+ has been determined. All five deuterium isotopes have been investigated. In the present work, reactions of the $CH_3O_2^+$ ion with over 20 neutrals have been studied. This allows a determination of the structure of the ion, H_2COOH^+, and its energy, $\Delta H_f \sim 186$ kcal mol^{-1}. Its modes of reactivity include OH^+ transfer to neutrals, H^- abstraction from alkanes, and proton transfer. This wealth of data yields a detailed picture of the reaction mechanism. First a long-lived $(O_2^+ \cdot CH_4)^*$ complex is formed ($\tau \sim 10^{-9}$s at 300K). This is followed by hydride ion transfer to produce $(CH_3^+ \cdot HO_2)^*$, which then ejects a hydrogen atom, leaving the product ion H_2COOH^+.

*Also, Aeronomy Laboratory, NOAA, Boulder.
#NRC Senior Research Associate, NOAA.

EA-2 Internal Energy Effects in Bimolecular Ion-Molecule Reactions, P.R. KEMPER, J. PEARSON, T. O'KEEFE, and M.T. BOWERS, Dept. of Chemistry, Univ. of California, Santa Barbara, Ca 93106--A tandem ion cyclotron resonance technique has been developed for creating reactant ions with known and variable amounts of internal energy. These ions are then mass selected and injected at low translational energy (≤0.5eV lab) into a differentially pumped ICR reaction cell where absolute rate constants and branching ratios are measured. Semiquantitative kinetic energy dependence of the same reactions can also be measured in this cell. Systems that will be discussed include $NH_3^+(v)/D_2$, $ND_3^+(v)/H_2$, $NH_3^+(v)/CD_4$ and $C_2^+(^2\Pi_u)$, $C_2^+(^4\Sigma_g^-)$ reacting with CH_4, C_2H_2, C_2H_4 and HCN. The reactant $NH_3^+(v)$ ion vibrational energy can be varied from 0 to 5eV and C_2^+ selectively formed in either its ground $^4\Sigma_g^-$ state or the $^2\Pi_u$ state approximately 0.8eV higher in energy.

EA-3 Predicting the Temperature Dependences of Ion-Molecule Association Reactions in the Low Pressure Limit, A.A. VIGGIANO and JOHN F. PAULSON, AFGL, Hanscom AFB, MA 01731 --The theories of Herbst[1] and Bates[2] have been successful in predicting the temperature dependence of many ion-molecule association reactions in the low pressure regime. Recently several systems have been studied that have larger temperature dependences than those predicted by the $T^{-l/2+\delta}$ rule where l is the number of rotational degrees of freedom in the reactants and δ is a small correction. We have used these theories with the inclusion of vibrational contributions to predict the temperature dependence of association reactions in which the reactants have low lying vibrations. The calculations give good agreement with experimental results. The systems include HSO_4^-+HCl, Br^-+WF_6, CH_3^++CO_2 and $NO_3^-(HNO_3)$+HCl.

[1]E. Herbst, Chem. Phys., 68, 323 (1982) and reference therein.

[2]D.R. Bates, Chem. Phys. Lett., 112, 41 (1984) and references therein.

EA-4 Investigation of Mechanisms of Charge Transfer Reactions Using Crossed Molecular Beams, DU WEN HU, B. FRIEDRICH, A. ROCKWOOD, S. HOWARD, P. TOSI, W. LINDINGER, and J.H. FUTRELL, Department of Chemistry, University of Utah, Salt Lake City, Utah--The crossed molecular beam method was used to investigate the state-to-state reaction dynamics of charge transfer in atomic ion-atom, atomic ion-diatomic molecule, and diatomic ion-diatomic molecule systems. The measurement of angular scattering along with translational energy exchange in these systems provides detailed information on both energy transfer and mechanisms of charge transfer reactions. The systems investigated (rare gases and simple diatomics) provide examples of symmetric resonance, vibrational state-specific charge and energy transfer, extensive energy mixing, direct and orbiting complex mechanisms, depending upon the collision partners and collision energies.

EA-5 The Reactions of $Ar^+(^2P_{3/2})$ and $Ar^+(^2P_{1/2})$ with O_2 from 0.04 eV to 3 eV, M. HAMDAN, K. BIRKINSHAW, Department of Physics, University of Wales, Aberystwyth, Dyfed SY23 3BZ, U.K.--The reactions of $Ar^+(^2P_{3/2})$ and $Ar^+(^2P_{1/2})$ with O_2 have been studied using a selected ion flow drift tube over the collision energy range 0.04 eV to 3 eV. Over the whole energy range collisional quenching of $Ar^+(^2P_{1/2})$ occurs and the $Ar^+(^2P_{3/2})$ reacts with O_2 more rapidly than $Ar^+(^2P_{1/2})$, charge transfer being the only reaction channel. Above 0.3 eV the excitation of $Ar^+(^2P_{3/2})$ to $Ar^+(^2P_{1/2})$ by O_2 has been observed and the rate of this process rises rapidly with collision energy. A new method of data analysis is described which provides the rate constant for the excitation process as well as the rate constants for the reaction of the $Ar^+(^2P_{3/2})$ and the reaction and quenching of the $Ar^+(^2P_{1/2})$.

EA-6 Molecular Dynamics Studies of the Charge-Transfer Reaction $Ar^+(^2P_{3/2}) + N_2(\Sigma_g, v=0) = N_2^+(^2\Sigma_g) + Ar(^1S_0)$ at Low and Intermediate Energies, J.H. PUTRELL, A. ROCKWOOD, S. HOWARD, Y.T. LONG, P. TOSI, A. SHUKLA, and K. BIRKINSHAW, Department of Chemistry, University of Utah, Salt Lake City, Utah--The title reaction has provided some of the most intriguing results yet obtained on the dynamics of charge-transfer reactions. The simplest interpretation of Newton diagrams constructed from the scattering data is that the reaction is highly quantum-state-specific, generating the product N_2 primarily in the first vibrational level. The angular scattering is also quite specific, occurring primarily at 180° (with respect to the initial ion velocity vector) at energies about 1.5 eV. At 0.6 eV orbiting collisions are found, suggesting a relatively deep (approximately 1 eV) potential well for ArN_2^+. At 1.1 eV the simplest interpretation of the scattering diagram is that vibrational levels 1, 2, and 3 of the product ion are all populated with significant probability and that these products are generated in an angular-specific manner.

EA-7 Strong Acids and High Electron Affinities, JOHN F. PAULSON, A.A. VIGGIANO, and MICHAEL J. HENCHMAN, AFGL, Hanscom AFB, MA 01731 --An acid is considered to be a species with a strong tendency to donate protons or to accept electrons. We have undertaken a study at 350K in the gas phase of the ion chemistry of several species known to be strong acids in liquid solution. The species are HX where X is NO_3, HSO_4, CF_3SO_3, FSO_3, and $ClSO_3$. Emphasis was placed on determining lower bounds for the electron affinities of the species X by measuring the rates for dissociative charge transfer reactions of several negative ion species with HX. The electron affinity of CF_3SO_3 was determined in this way to be greater than 5 eV.

SESSION EB

10:00, Wednesday, October 16, 1985

DC - GLOWS

Chairperson: A.K. Bhattacharya
General Electric Co

EB-1 Profile of vibrational temperature in an axial-flow, longitudinal N_2 discharge, S. ONO and S. TEII
Musashi Institute of Technology, Setagaya-Ku, Tokyo, Japan -- The study of vibrational excitation of molecules has recently been of interest in the area of molecular lasers and plasma chemistry. The vibrational temperature Tv in a discharge tube is known to be affected by electron temperature and electron density of the plasma[1] as well as by the gas velocity in the tube[2]. In the present study, axial variation of Tv in a gas flowing longitudinal N_2 discharge tube has been numerically calculated by taking into account the V-e, V-T energy transfer and the effect of gas velocity. The results predict that (1) Value of Tv increase downstream and has a saturation value at locations corresponding to a residence time of about 10 msec; (2) Tv changes with the radius of discharge tube due to the collisions of vibrational excited nitrogen molecules with the tubes' wall. Experiment has been also conducted and the results agree well with the theoretical predictions.

1) S. Ono and S. Teii, J. Phys. D: Appl. Phys. 16, 163 (1983).
2) S. Ono and S. Teii, 40 th Annual JPN, Phys., Soc. Conf. 4-105 (1985).

EB-2 Spatial Dependence of Light Emission from N_2 Discharges at Very High E/n.* B. JELENKOVIC† and A.V. PHELPS,‡ JILA, Univ. of Colo. & NBS.--Normalized spatially dependent excitation coefficients -- $(j/j_a)(\alpha_{ex}/n)$ -- for emission from the $B^2\Sigma$ (391.4 nm) state of N_2^+ and relative coefficients for the $B^3\Sigma$ (670.4 nm) state of N_2 were measured for steady-state, low pressure N_2 discharges. The E/n were 250 to 78,000 Td (1 Td = 10^{-21} V m^2) for an electrode spacing of 38 mm, N_2 densities of 1.8×10^{21} to 1.3×10^{23} m^{-3}, and current <1 μA. At the lower E/n both band intensities increase exponentially with distance from the cathode as expected from published ionization coefficients. At the higher E/n the 670.4 nm emission decreased exponentially by a factor of 30 with distance from the cathode, while the 391.4 nm emission decreased only a factor of 2. Current models for the 670.4 nm emission at high E/n invoke ion-induced excited species leaving the cathode. The 391.4 nm emission is closer to that expected for electron excitation.

*Supported in part by LLNL and AFOSR.
†On leave from Institute of Physics, Belgrade.
‡Staff Member, Quantum Physics Division, NBS.

EB-3 Optogalvanic Spectroscopic Measurement Of The Electric Field Vector In A Positive Column DC Discharge. B. N. Ganguly and Alan Garscadden, AFWAL/POOC -3, WPAFB OH 45433. The magnetic quantum number selection rule implies that radiation that is linearly polarized perpendicular to the electric field will not excite $\Delta M = 0$ transitions. This phenomenon in Stark spectra of high ($n > 25$) Rydberg states of atomic helium has been used to measure the electric field vector in a positive column, where the field direction changes from essentially radial at sheath boundary to axial in the center of the discharge column. The electric field magnitude is measured from the Stark line broadening[1] and also from the relative intensities of the allowed to forbidden transitions[2] for $\Delta M = 0$ transitions. In this low pressure, low current discharge, the angular resolution of the field direction was measured to be $\pm$ 5 degrees.

1. H. R. Griem, Spectral Line Broadening by Plasmas (Academic, NY, 1974).
2. H. A. Bethe and E. E. Saltpeter, Quantum Mechanics of One- and Two- Electron Atoms (Plenum, NY, 1977).

EB-4 Radial Distribution of Mercury Isotopes in a Low Pressure Hg-Ar Discharge, M.W. Grossman, R. Lagushenko and J. Maya, GTE Lighting Products-Danvers MA--Using a novel quartz fiber optic-Fabry Perot interferometer technique, radial distribution of the hyperfine structure (hfs) of the Hg(6^3P_1-6^1S_0) transition in a low pressure Hg-Ar discharge has been measured. Using a numerical procedure for the solution of the modified Holstein-Biberman(1) equation, the radial profile of the electron excitation function is obtained by fitting the experimental (hfs) to the calculated one. The dependence of the radial distribution of the different isotopes on the shape of the excitation function, discharge conditions and isotopic composition is reported. The effect of the particular form of radial distribution of each isotope on radiation efficiency is discussed.

(1)M.W. Grossman, R. Lagushenko and J. Maya Journal of App. Phys. (in press);
J. Maya, M.W. Grossman, R. Lagushenko and J. Waymouth, Science 226, 435 (1984)

EB-5 Magnetic Control of Low Pressure Gas Discharges,* J.R. Cooper and K. H. Schoenbach, Old Dominion University, Norfolk, Virginia 23508 and G. Schaefer, Texas Tech University, Lubbock, Texas 79409--The positive column of a low pressure gas discharge in a transverse magnetic field was modeled using a Monte Carlo code. Due to the shift of the electron energy distribution towards lower energies the ionization coefficient is reduced when the magnetic field B is applied. In a gas mixture containing an electronegative gas with the attachment cross section peaking at values below the mean energy of the electron distribution, the magnetic field causes additionally an increase in the attachement rate coefficient. In a gas mixture of He and SF_6 (80%: 20%) at about 10 Torr, both mechanisms lead to a sharp rise of the equilibrium electric field in the positive column above a threshold value of B~0.4 T. This effect offers a means to use low pressure discharges, operated above the pd-value of the Paschen minimum, as magnetically controlled opening switches.

*Work Supported by GTE Laboratories, Inc. and the Center for Energy Research, Texas Tech University

EB-6 Thyratron Modeling Using A Plasma Particle Simulation*, M.J. Kushner, R.A. Petr and C.H. Fisher Spectra Technology, Inc. (Formerly Mathematical Sciences NW) --A model for the electron avalanche and commuation of a thyratron having a linear geometry has been developed using a plasma particle simulation. The simulation uses the Monte-Carlo technique and a renormalization scheme to model the electron avalanche in 3D for an arbitrary grid geometry in He, Ne or Xe. A model for the external circuit enables computation of V-I characteristics. Heavy particle kinetics and transport are simultaneously solved for using quasi-continuum continuity and momentum equations thereby enabling solution of Poisson's equation for the local electric potential. Collisions from the electron particle simulation are used as source terms in the heavy particle continuity equations. A null-cross section like algorithm is used to include excited state, electron-ion and electron-electron collisions. Comparison is made to experimental measurements of excited states and discharge emission. Conceptual designs of new thyratrons are discussed.

*Work supported by AFSC Contract F33615-84-C-2474

EB-7 Rapid Analysis of Discharge Kinetics Data in Externally Sustained Discharges,* M. vonDADELSZEN, Tetra Corporation--A re-parameterization of the electron number density rate equation has identified a curvefitting procedure which enables the simultaneous acquisition of electron drift velocities, attachment and recombination rates and ionization source strengths in externally sustained diffuse discharges for a wide range of gas mixes. The procedure was developed for investigating UV sustained discharges, using simultaneous discharge current and photodetector traces, but is equally applicable to other external sources. The ease and speed of measurement compensates for the somewhat reduced accuracy of the method compared to more direct measurements. The approach will be outlined and some data presented.

*Work supported by Army Research Office.

EB-8 An Analysis of the Cathode Spot Distributions in High Pressure, Externally Sustained Glow Discharges,* MICHAEL VON DADELSZEN, Tetra Corporation -- Investigations into the stability of high pressure, externally sustained glow discharges indicate that streamers generated above the cathode surface are a dominant mechanism in driving the glow discharge to arc transition. These streamers arise from cathode spots observed over the cathode surface. The cathode spots are due to greater current densities in the cathode fall than in the glow positive column. There is, currently, no analysis published which predicts or analyzes the cathode spot distributions. An approach will be presented, whereby the problem is divided into separate regions, enabling an analytical solution to the problem. The solutions predict spot distributions very close to those observed experimentally. Variables include pressure, source strength and the positive column current density and electric field. The gas examined is pure nitrogen.

*Work supported in part by Air Force Office of Scientific Research.

SESSION FA

13:00, Wednesday, October 16, 1985

ELECTRON-MOLECULE COLLISIONS: TOTAL SCATTERING AND EXCITATION

Chairperson: R. St. John
U. of Oklahoma

FA-1 Measurements and Calculations of Electron Beam Growth in N_2,* P.C.F. IP and W.A.M. BLUMBERG, Air Force Geophysics Laboratory, Hanscom AFB, MA 01731, B.D. GREEN , W.J. MARINELLI, and G.E. CALEDONIA, Physical Sciences Inc., Research Park, Andover, MA 01810 -- Spatial distributions of electrons scattered out of a collimated electron beam incident on low pressure N_2 targets have been measured and calculated. Spatial distributions were obtained for beams of 2-6 keV electrons propagating through target thicknesses of 0.05-3.5 Torr-cm. The growth of the electron beam was measured with a calibrated, two-dimensional scanning photometer which monitored the N_2^+ fluorescence excited by energetic electrons. Radial electron density distributions were obtained using Abel inversion techniques. Measured electron density distributions will be compared with Monte Carlo calculations of the contribution of elastic scattering to the observed beam growth. These results will also be compared with prior measurements and calculations reported for higher electron energies and greater target thicknesses.

* Supported by the Air Force Office of Scientific Research and the Defense Nuclear Agency.

FA-2 Relative Excitation Efficiencies of N_2 Electronic States* B.D. Green and W.J. Marinelli, Physical Sciences Inc., Andover, MA and W.A.M. Blumberg Air Force Geophysics Laboratories, Hanscom AFB--Fluorescent intensities from electron-irradiated N_2 have been measured in a large scale apparatus (LABCEDE) at pressures sufficiently low (1.6×10^{19} m^{-3}) that molecular collisional energy transfer occurs at a slower rate than radiative decay. The molecular fluorescence from pure N_2 was spectrally resolved using a monochromator and an interferometer. Continuous spectral coverage between 170 nm and 5 μm was achieved. States (and transitions) observed include the a (Lyman-Birge-Hopfield), C(Second Positive), B(First Positive), B'(IR Airglow), W(Wu-Benesch) and the ionic A(Meinel) and B(First Negative). Relative populations and vibrational distributions in the various excited electronic states were accurately determined through comparison of theoretical spectra with the complex fluorescent intensities. The neutral state populations determined in this manner agree well with previous auroral, laboratory, or theoretical predictions.

*Work supported by Air Force Office of Scientific Research and Defense Nuclear Agency.

FA-3 Low-Energy, Small-Angle Scattering of Electrons by Alkali-Halide Molecules--G. F. SHEN, M. ZUO, B. STUMPF, B. JADUSZLIWER,* and B. BEDERSON, New York University** --We present preliminary data on the scattering of low-energy electron by alkali-halide molecules, using the molecular beam "recoil" technique, in which observation is made of the scattered molecule, rather than the electron. This technique allows for the determination of absolute cross sections without normalization. It is also capable of observing very small angle scattering, of the order of several degrees, because it is possible to observe scattering within the "shadow" of the unscattered beam. Four groups of measurements are presented, at 5 and 20 eV, for Cs Cℓ and LiBr, from ~ 4 to 20°. In one case (5 eV, CsCℓ) we are able to directly compare our measurements with early ones of Stern and colleagues;[1] the agreement appears to be reasonably good. In several cases we observe significant oscillation in the differential cross section. Comparison with available calculations will be made.

[1]W. Becker, M. Fickers, R. Slater, and R. Stern, J. Chem. Phys. 61, 2283 (1974).

*Aerospace Corporation

**Supported by US DOE, Division of Basic Energy Sciences

FA-4 Vibrational Excitation of HF Molecules by Slow Electron Impact: Effects of Polarization.* A. JAIN and D.W. NORCROSS,† JILA, U. of Colo. & NBS -- Vibrational excitation (from v=0 to v'=0 and 1) of HF molecules by slow electrons is studied in the adiabatic-nuclei approximation. Exchange is treated exactly through a separable approximation and correlation-polarization via a parameter-free local potential. Previous similar calculations of Resigno et al.,[1] which totally ignored target distortion, change by about a factor of two, when polarization is considered (giving better agreement with the experiment). At 2 eV, the present differential cross section (DCS) for 0 → 1 excitation compare satisfactorily with the measurements.[2] Although there is no 2 ~ 3 eV resonance structure like HCℓ, the DCS shows forward peaking in this region, which may be due to some direct vibrational excitation.

*Supported by the U.S. Department of Energy (OBES).
†Staff Member, Quantum Physics Division, NBS.

[1]T.N. Resigno, A.E. Orel, A.U. Hazi and B.V. McKoy, Phys. Rev. A 26, 690 (1982).
[2]K. Rohr and F. Linder, J. Phys. B 9, 2521 (1976).

FA-5 Absolute Low Energy Differential Elastic Scattering Cross Sections in He and H_2, D.E. GOLDEN, NORTH TEXAS STATE UNIVERSITY, DENTON TX 76203.
Absolute-electron impact elastic differential cross sections in He and H_2 have been determined from relative scattered electronangular distribution measurements in the energy range from 1 to 19eV by using a pulsed time-of-flight technique. The S,P, and d wave phase shifts determined in this work for He are in agreement with previous determinations. The He total and momentum transfer cross sections derived from the fitted phase shifts agree best with those previously determined by Golden and Bandel and Crompton et.al., respectively. The absolute cross sections determined in this work for H_2 are in excellent agreement with recent full rovibrational laboratory-frame close-coupling calculations. The present measurement technique will be discussed and the results compared with previous measurements and calculations.

SESSION FB

13:00, Wednesday, October 16, 1985

PLASMA CHEMISTRY

Chairperson: R.A. Gottscho
AT&T Bell Labs

FB-1 Extraction of volume-produced H^- ions. M. BACAL and F. HILLION, Ecole Polytechnique. The extraction of negative particles from the volume of H_2/D_2 hybrid magnetic multicusp plasma, presents several unexpected features. Although the negative particles are electrostatically confined by the positive plasma potential, they seem to be able to flow out of the plasma in amounts, comparable to (in the case of electrons), or larger than (in the case of negative ions) the respective thermal fluxes. A positive bias applied to the plasma electrode of the extractor can increase the negative ion current but reduces the electron current. The dependence between the extracted negative ion current and the negative ion density in the plasma (measured by photodetachment) will be presented ; the results will be analyzed in terms of atomic and molecular processes determining the negative ion energy in the plasma.

FB-2 Electron Kinetics in Low Pressure SF_6 Etching Discharges. L. E. KLINE, Westinghouse R&D, Pittsburgh, PA 15235 - - The electric field to gas density ratios are high (E/n $\geq$1000 Td) in low pressure (p $<$ 0.5 Torr) RF discharges.[1] Monte Carlo simulation and time dependent Boltzmann equation solutions have been used to study the electron kinetics in SF_6 at high E/n. SF_6 dissociation rates have been estimated by assuming that all electronic excitation of SF_6 is dissociative in analogy with the known product channels in ionization and multiphoton dissociation. The calculated electron energy relaxation time for p$\geq$ 0.1 Torr is much shorter than the 74 ns period at 13.56 MHz. Consequently, the electrons are nearly in equilibrium with the time and space dependent electric field in these discharges. Furthermore, the time scale of the chemical kinetics is much longer than the period of the applied RF voltage. Therefore, the rate coefficient values which correspond to the time and space averaged electric field can be used in chemical kinetics models.
1) C. M. Horwitz, J. Vac. Sci. Technol. A1, 60 (1983).

FB-3 Chemical kinetics in Low Pressure SF_6 Etching Discharges, L. E. KLINE, Westinghouse R&D, Pittsburgh, PA 15235 - - A rate equation model has been used to study the chemical kinetic processes in plasma etching discharges in SF_6. Electron impact dissociation and ionization are the dominant sources of chemically active species for typical conditions where the value of E/n is several times higher than the limiting value, $(E/n)^*$. The ionization and attachment rates are equal when $E/n = (E/n)^*$. Dissociative attachment makes a small contribution to the total dissociation rate under these conditions. Charged and neutral particle fluxes to the silicon wafer surface are estimated by using ambipolar and free diffusion rates, respectively. The diffusion coefficients are assumed to depend on the probability of reflection at the surface as well as on the pressure and the identity of the diffusing species. The predicted particle flux to the silicon wafer surface is dominated by neutral F and SF_5 and the predicted etching rate due to these species is at the low end of the experimentally observed range for typical experimental conditions.

FB-4 Measured and Predicted $a-C:H$ Deposition Rates in RF Discharges in CH_4, L. E. KLINE and W. D. PARTLOW, Westinghouse R&D Center, Pittsburgh, PA 15235 - We have measured the deposition rate as a function of the discharge power, gas pressure and flow rate and the substrate electrode bias. The other experimental measurements include emission spectra, downstream mass spectra, floating probe potentials and voltage and current waveforms. The measured fractional dissociation and deposition rate increase as the discharge power increases and as the gas flow rate decreases. Calculated time and space averaged values of electron impact dissociation and ionization rate coefficients were used in a rate equation model which follows a "slug" of gas as it flows through the reactor and dowmstream to the mass spectrometer. The model also includes gas phase reactions, diffusive transport, and a variable surface reflection coefficient for the activated species. The trends in the predicted deposition and dissociation rates agree with the experimental results.
Supported in part by AFOSR Contract F49260-84-C-0063DEF

FB-5 MECHANISTIC STUDY OF REACTIVE ION ETCHING OF SI AND SiO_2, G. Fortuno, IBM. A study of the optical emission, the mass spectra, and of the Si and SiO_2 etch rates during reactive ion etching (RIE) was made in an attempt to understand some of the chemical mechanisms involved in these processes. CF_4, CF_3Cl, CF_2Cl_2, and $CFCl_3$ gases were used in order to observe the differences and similarities in changing the number of Cl and F atoms in the parent molecule. The etch rates of Si, SiO_2, and multi-level resist (MLR), as well as the plasma and the sheath voltages, were measured. A measurable dependence of the optical emission intensities of F, Cl, and CF_2 and of the Si etch rate on the temperature of the wafer was observed in all cases. The activation energy was determined for etching Si in CF_4. The sheath voltage and the oxide etch rate increase with F/Cl ratio. For each gas, the oxide rate was measured as a function of sheath voltage which was varied by splitting the power between top and bottom electrodes. The etch rate of oxide has a strong dependence on the sheath voltage, as if dominated by physical sputtering. The etch rate of Si depends more on the gas composition, and it seems to be dominated by ion assisted chemical etching.

FB-6 Applications of the New Kinetic Many-Body Theory of Interactions of Low Energy Plasma Particles with Surfaces, YU.L. KHAIT, Dept. Phys., Ben Gurion Univ., Beer Sheva, Israel --Basic ideas and applications to sputtering[1] and plasma coating[2] of the novel kinetic many-body theory of interactions of low energy plasma particles (LEPP's) which involve projectiles and recoil material atoms in the energy range of $\mathcal{E} \approx 1$ to 10^3eV are considered. These results are based on applications and modifications of qualitatively new concepts, methods and results obtained in the kinetic many-body theory of short-lived large energy fluctuations (SLEF's) of single particles in solids and on their surfaces and of SLEF-assisted atomic and electronic rate processes and melting which are summarized in the review[3]. Comparisons of calculations and experimental data show their agreement[1,2].

[1]Yu.L. Khait, J.Low Temperature Plasma Chem., January (1985).

[2]Yu.L. Khait, Thin Solid Films 72, 249 (1980).

[3]Yu.L. Khait, Physics Reports 99, 237-340 (1983).

SESSION G

14:45, Wednesday, October 16, 1985

SYMPOSIUM ON ION-MOLECULE REACTIONS

Moderator: E.E. Ferguson
NOAA

G-1 PRODUCTION AND LOSS PROCESSES IN LOW TEMPERATURE PLASMAS. D. Smith, U. of Birmingham, United Kingdom

G-2 Effect of Ion Internal States on Ion-Molecule Reactions,* R.N. Zare, Department of Chemistry, Stanford University, Stanford, CA 94305 -- Multiphoton ionization (MPI) in combination with time-of-flight photoelectron energy analysis provides a powerful new means for preparing state-selected reagent ions for reaction dynamics studies. Indeed, this is an obvious extension of the classic study of Chupka and coworkers[1] on $H_2^+(v) + H_2 \rightarrow H_3^+ + H$ in which different vibrational levels of H_2^+ were selected by one-photon vacuum ultraviolet photoionization of H_2. We use resonance enhanced 2+1 multiphoton ionization to prepare NH_3^+ in selected vibrational levels of the v_2 umbrella bending mode.[2] Reactions of $NH_3^+(v)$ with $H_2(D_2)$, $NH_3(ND_3)$, and $H_2O(D_2O)$ have been carried out as a function of reagent ion velocity and vibrational excitation. Preliminary results will be reported.

*Work supported in part by the Air Force Office of Scientific Research.

[1]W.A. Chupka, M.E. Russell, and K. Rafaey, J. Chem. Phys. 48, 1518 (1968).

[2]W.E. Conaway, R.J.S. Morrison, and R.N. Zare, Chem. Phys. Lett. 113, 429 (1985); R.J.S. Morrison, W.E. Conaway, and R.N. Zare, ibid. 113, 435 (1985).

G-3 TRANSLATIONAL AND ELECTRONIC ENERGY DEPENDENCE OF ION-MOLECULE REACTIONS. P.Armentrout, U. of California-Berkeley

G-4 THREE-BODY ION MOLECULE REACTIONS. R. Johnsen, U. of Pittsburg

SESSION H

08:00, Thursday, October 17

BREAKDOWN

Chairperson: J. Proud
GTE Labs

H-1 Wave Structure in Progressive Breakdown. M. HEMMATI* and R.G. FOWLER, U Okla.** --A detailed survey has been completed of the possible solutions of Shelton's electron-fluid dynamical equations (slightly modified), both for proforce and antiforce wave breakdown into ionized or non-ionized media, with or without a large following current. The wave speeds are consistent with the experiments of Scott, and the general information for natural lightning. No solutions were found above a certain level of preionization, or for proforce waves followed by large currents. Profiles of electron concentration, temperature, and velocity, and of the electric intensity, as they vary with position through the wave, will be given. An ionization function derived by Fowler which allows for the grossly non-equilibrium character of the electron distribution was used.

*Arkansas Tech U, Russelville AR.

**Supported by NSF Grant ATM7918510.

G. Shelton Jr and R. Fowler, Phys Flds 11,1521
R. Scott and R. Fowler, Phys Flds 18,1433
R. Fowler, J Phys B 16,4495

H-2 Water Vapor-Enhanced Electron Avalanche Growth in SF_6 for Nonuniform Fields,* R. J. VAN BRUNT, National Bureau of Standards -- When water vapor content is increased from about .10 to 200 ppm_v in SF_6 at pressures of 100 to 300 kPa, a dramatic enhancement occurs in the mean size of electron avalanches formed near a positive point electrode. This effect is due to changes in gas composition, but cannot be attributed to the resulting small changes in the ionization rate. A mechanism is proposed involving an increase in the probability for avalanche initiating electron release through generation of minor negative ion, or ion cluster species such as $(H_2O)_n^-$ (n=1,2,...) that collisionally detach more readily at a given field strength than the expected predominant $SF_6^-(H_2O)_n$ ions. For avalanches with fewer than 10^7 electrons, the distributions exhibit the usual exponential shape[1], but pronounced peaks appear as the mean size exceeds this value.

*Supported by U. S. Department of Energy

[1]W. Legler, Z. Naturforsch. 16A, 253 (1963).

H-3 Transient Ionization and Excitation Rates at High E/N,* G. N. Hays, L. C. Pitchfordt, J. B. Gerardo, and J. T. Verdeyen=, Sandia National Laboratories--We will report the time dependence of the electron density and excitation light for values of E/N between 500 and 15000 Td. The avalanche is created by subjecting an initial plasma of ~ 10^6 cm^{-3} imbedded in an axial magnetic field to a fast rising 200-watt microwave pulse tuned to electron-cyclotron-resonance (ECR). The buildup of the electron density is monitored by a low-power microwave interferometer with a sensitivity of 10^6 cm^{-3} and a time resolution of 1 nsec. Under the circumstances of ECR, the electron dynamics are equivalent to that of a pulsed DC experiment without electrode complications. The ionization rate is determined from the exponential growth of the electron density as determined by the interferometer, the absorption on the high-power pulse, and the excitation light; good agreement between these methods is achieved. The experimental results and nonequilibrium Boltzmann calculations agree to within 20% for N_2.

*This work supported by the U. S. Dept. of Energy.

†GTE Laboratories, Inc., Waltham, MA 02254.

=University of Illinois, Urbana, IL 61801.

H-4 Operation of Externally Ionized Discharges at High Electric Fields, P. Bletzinger, Air Force Wright Aeronautical Laboratories--Externally ionized discharges can be operated with widely variable reduced electric fields (E/N). The maximum E/N is limited by instabilities causing breakdown from diffuse to arc discharges, for example to about 30 Townsend in N2. Using an inductive load, a voltage pulse is applied to the discharge when the ionization (E-beam) is switched off and E/N values of more than 100 Townsend without breakdown have been measured, exceeding the breakdown voltage of the discharge gap without ionization. The pulse width is a function of the discharge decay time; slow recombination has been shortened by adding attaching gases. Over a wide range, up to .16 J/cm3, the E/N limit was found to be independent of power loading. If the E/N limit is exceeded, breakdown occurs as much as 200 usec after ionization is switched off. The high E/N values which have been observed are useful for high voltage switching; other applications include efficient excitation of electronic states.

H-5 Applications to Pulsed Gas Discharges and Lasers of the Novel Statistical Kinetic Theory of Transient Electronic Phenomena in Gases in Electric Fields, Yu.L. KHAIT, Dept.of Phys., Ben Gurion Univ., Beer Sheva, Israel -- Basic ideas and applications to electron avalanches in CH_4 and N_2 and to nanosecond pulsed discharge lasers in N_2 of the new non-equilibrium non-stationary statistical theory of transient electronic phenomena in gases in electric fields E are considered[1]. Here E and particle density N satisfy the conditions $eE \ll W_0 N\sigma$, where σ is the cross section of electron-molecule collisions, W_0 is the ionization potential. Characteristic time and space intervals, wedge angles of avalanches, ionization coefficients, etc are calculated and an agreement between calculated and experimental data is found[1].

[1]Yu.L. Khait, Proc.6th Int,Symp.Plasma Chemistry, Montreal, 1983. In MGD-Flows and Turbulence, the Amer.Inst. Astronautic and Aeronautic Progress Series, ed. H. Branower and M. Sommerfield, 1985. Jorn. Phys. (Paris), C-9, 41, 317 (1980). Proc. ESCAMPIG 84, Bary, 1984. Abstr. XIVth Int. Conf. Statistical Physics, Alberta (1980). Invited Paper at Int. Work shop Plasma Chem.in Technology, Ashkelon, 1981.

H-6 Plasma Channel Formation over Electrically Heated Silicon Films.* D. A. BENSON and R. W. BICKES, JR., Sandia National Laboratories -- Results are reported for the resistive heating of 2 to 4 μm thick films of n-doped Si which causes melting, vaporization, and eventually, plasma formation. The films are heated in a few microseconds with potentials in the range of 0.2 V/μm. High-speed photography and electrical diagnostics have revealed a novel 2-stage discharge process. In the first stage, the falling resistance of Si with increasing temperature produces a longitudinal heating instability. This results in a luminous front which propagates transversely across the silicon film, vaporizing and weakly ionizing the silicon. When the film has been completely vaporized, the vapor provides a dense gaseous conductor spanning the electrical contacts of the device. During the second discharge stage this dense gaseous material can be resistively heated to produce an excited plasma. The dynamic electrical impedance, as well as initial measurements of the pressure in the vapor confined over these devices will be described. Potential applications in electrical switching, pulsed plasma and light sources may exist with this technology.

*Work supported by the US Dept of Energy under contract DE-ACO4-DP00789.

SESSION I

09:50, Thursday, October 17

LOEB COMMEMORATIVE SESSION

Chairperson: Leon H. Fisher

I

I-1 EARLY WORK ON ELECTRICAL BREAKDOWN IN GASES. L.H. Fisher.

Leon H. Fisher, a former student of L.B. Loeb, chaired the first Gaseous Electronics Conference. Leonard Loeb, himself, was an active participant in the GEC and left a legacy of inspiration to his undergraduate and doctoral students alike. Among his doctoral students were:

Hooper, William James		1926
Cravath, Austin M.		1928
Mahoney, Jerry Joseph		1928
Marshall, Lauritson C.		1929
Luhr, Overton		1930
Bradbury, Norris Edwin		1932
Sanders, Frederick Henry		1932
Ko, Cheng-Chuan	May	1933
Finney, Gladys Donaldine	Dec.	1934
Varney, Robert Nathan	May	1935
Posin, Daniel Q.	May	1935
Gardner, Milton Eugene	June	1937
Bowls, Noodford Eugene	Nov.	1937
Chapman, Seville	May	1938
Ehrenkranz, Florence Anna	May	1938
Trichel, Gervais William	May	1938
Hershey, Allen Vincent	July	1938
Kip, Arthur Frederic	March	1939
Gorrill, William Sterling	March	1939
Hale, Donald Herbert	Sept.	1939
Weissler, Gerhard Ludwig	May	1942
Geballe, Ronald	Oct.	1942
Fisher, Leon Harold	Sept.	1943
Morton, Paul Lester	Aug.	1943
Debeau, David Edmond	May	1944
McReynolds, Andrew Wetherbee	Feb.	1945
Koller, Ruedi	Feb.	1946
Johnson, Gerald Woodrow	Feb.	1947
English, William Noel	Jan.	1948
Miller, Charles G.	June	1949
Lauer, Eugene John	June	1951
Kunkel, Wulf Bernard	Sept.	1951
Dodd, Edward Elliot	Jan.	1952
Stein, Robert Preston	June	1952
Theobald, Jacob Karl	Jan.	1953
Amin, Mohammad Reza	June	1953
Bradley, Richard Crane	Sept.	1953
Peterson, John Wright	Sept.	1953
Hurlbut, Franklin Charles	Jan.	1954
Parker, James Henry, Jr.	Jan.	1954
Bandel, Herman William	June	1954
Evans, Ralph Aiken	June	1954
Huber, Elsa Louise	June	1954
Maunsell, Charles Dudley	Jan.	1955
Warren, Roger Wright	Jan.	1955
Gardner, Andrew Leroy (with W. Kunkel)	Sept.	1955
Wagner, Peter Ewing	Sept.	1956
Rohatgi, Vijay Kiemar	June	1957
Hudson, Gilbert Glover	Sept.	1957
Westberg, Russel George	Jan.	1958
Waters, Paul McElroy	June	1958
El-Bakkal, Jafar Mehdi	June	1960
Muray, Julius J.	June	1961
Dowell, Jerry Tray	Feb.	1966
MacLennan, Donald Allan	June	1966
Winn, William Paul	June	1966
Burrow, Paul David	Dec.	1966
Hassoun, Abbass Mohd	June	1967
Borst, Walter	March	1968
Breunig, James L.	Sept.	1972
Estrella, Rogelio Moreno	June	1975
Lanzaro, Andre	Dec.	1975

I-2 Violations of Paschen's Law,* L. G. CHRISTOPHOROU and S. R. HUNTER, Oak Ridge National Laboratory--According to Paschen's law, the uniform field breakdown voltage V_s of a gas is only a function of Nd_s (the product of gas density N and electrode separation d). For most gases $V_s/(Nd_s) \equiv (E/N)_{lim}$ is independent of N at low E and moderate pressures P. At high P, however, $(E/N)_{lim}$ can vary less than linearly with N (e.g., for SF_6, N_2) due to electrode nonuniformities and surface effects. Also, recent studies showed that $(E/N)_{lim}$ can increase rather than decrease with N. Such violations were observed for N_2O, SO_2, OCS, 1-C_3F_6, C_3F_8, and n-C_4F_{10} for a range of N over which the rate constant for stable negative ion formation increases with N. Similarly, the V_s of several mixtures (e.g., OCS/SF_6, SO_2/SF_6, C_3F_8/SF_6, SO_2/1-C_3F_6, 1-C_3F_6/c-C_4F_8) was found to be higher in the mixture than in the component gases. These findings will be presented and discussed; they demonstrate the crucial role of electron attachment on V_s.

*Research sponsored by EES, USDOE, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

I-3 Ionization, Attachment and Limit Fields in SF_6/N_2 and $SF_6/CC\ell_2F_2$ Mixtures, M.F. Fréchette, IREQ, Varennes, Québec, CANADA--Prebreakdown ionization currents have been measured in SF_6/N_2 and $SF_6/CC\ell_2F_2$ by the steady-state Townsend method over the range of reduced fields $70 \leq E/p \leq 200$ V $cm^{-1}Torr^{-1}$. Nonlinear regression analysis using Marquardt's procedure is performed for evaluation of the ionization (α), attachment (η) and effective ionization ($\bar{\alpha}$) coefficients. Limit fields are obtained from the condition $\bar{\alpha}\ (E/p^*)=0$. Coefficients for the respective gases compare well with the available data from the literature with the exception of the attachment coefficient in SF_6 which shows a more pronounced decrease than the general trend as E/p increases. In the case of SF_6/N_2 mixtures, good agreement is found for the effective ionization coefficients. The attachment coefficients do not saturate but rather increase in proportion to the SF_6 content. In $SF_6/CC\ell_2F_2$, the variation of $\bar{\alpha}$ is found to be nonlinear with the percentage mixture ratio. The resulting limit fields exhibit small synergistic effects (±5% maximum). This mixture falls into the category of mixtures "electronegative/electronegative" whose electron attachment rates are independent of neutral density.

I-4 Small Sparks and Cathode Spots.* G. BARRETO and E. BARRETO. At. Sci. Res. Ctr. State Univ. of NY Albany, NY 12222

In a uniform field air-gap smaller than a critical avalanche there are no streamers. Instead, a succession of avalanches fills the gap with a glow that lasts $\sim 10^{-7}$ sec. Then, very rapidly ($\sim 10^{-8}$ sec) electron emission, from the onset of a cathode cell, changes the stored electrical energy into heat. This process is controlled by the electron pressure gradient at or near the cathode. In N_2 effective turbulent mixing between electrons leads to gas temperatures between 500 and 1000 °K. However, a small protrusion (25 μm) at the cathode changes the discharge into a filamentary hot channel ($\sim 10^4$ °K) even though no stable negative ions are possible and the protrusion is small enough to prevent the onset of corona pulses. These filamentary discharges resemble those in O_2 and suggest that in electronegative molecular gases rapid dissociative attachment during the glow state prevents diffusion and enhances electron pressure gradients. In air both types of sparks are observed.

* Work supported by the Office of Naval Research

I-5 The Formation and Propagation of Avalanches and Streamers in Electronegative Gases*, C. Wu and E.E. Kunhardt, Polytechnic Institute of New York--The effect of electron attachment on the formation and propagation of avalanches and streamers is studied in narrow and wide cylindrically symmetric discharges. A numerical technique has been developed, based on Flux Corrected Transport methods, to do the two-dimensional simulations. The technique can handle space-time dependent velocity fields and very steep gradients in both velocity and density. The simulations are done in SF_6-N_2 mixtures, for SF_6 concentrations ranging from 0% to 100%. The background pressure is taken to be 760 Torr, the overvoltage ranging from 20% to 200%, with different voltage rise times. Photoionization in the gas and cathode photo-electric effect are taken into consideration. The speed of the streamers is discussed. The criteria for getting a uniform discharge is also studied.

Work supported by the Office of Naval Research.

I-6 Common Parameterizations of Electron Swarm and Breakdown Data for Binary Gas Mixtures, R. J. VAN BRUNT, and M. C. SIDDAGANGAPPA, National Bureau of Standards -- A new method of parameterizing data on ionization and attachment coefficients for binary gas mixtures is proposed which provides more physical insight and allows more flexibility in fitting breakdown strength data than the simple Wieland Approximation[1]. The fitting parameters can be related to electron temperatures and attachment and momentum transfer cross sections for the individual gas components. The model assumes: 1) a linear combination of mean electron energies, 2) Maxwellian energy distributions, and 3) a separation of the variables F and E/N (F = mixture ratio, E/N = field-to-gas density ratio). Examination is possible of conditions under which pressure independent positive synergisms in breakdown strength occur. The model is successfully applied to various mixtures, e.g. SF_6/N_2 and $CC\ell_2F_2/N_2$, and should prove useful for cases where Boltzmann type calculations are not feasible.

[1]P. J. Chantry and R. E. Wootton, J. Appl. Phys. 54, 2731 (1981).

I-7 Computation of the Radius of a High Pressure Filamentary Discharge in Air during an Early Stage of the Channel Development, *H. Jurenka and E. Barreto, ASRC, SUNY at Albany -- The fluid dynamical description of ionizing waves has been proposed[1] to describe high voltage breakdown streamers in air. Sharper parts of a wavefront, where the electrical field is concentrated, propagate faster and develop into thin filaments. Here we describe the development of a filamentary, weakly ionized, discharge channel as a result of self-focusing of a 3-dim plane wave caused by a space charge intensified E ahead of the curved wavefront. The mathematical description is analogous to self-focusing of light beams in non-linear optics. The stability analysis, performed on the 3-dim non-linear Schrödinger eq. (obtained previously[2] in 1-dim form from the full system of electron fluid and Maxwell's eqs.) gives the condition for the onset of a lateral instability. The result is a narrowing of the ionized region into a filamentary structure. The formula for the radius of a developing channel is given.

*Work supported by ONR

[1]N.W.Albright and D.A.Tidman, Phys.Fluids, 15,86 (1972).
[2]H.Jurenka and E.Barreto, J.Appl.Phys., 53, 3581 (1982).

SESSION JA

13:30, Thursday, October 17, 1985

HEAVY PARTICLE COLLISIONS

Chairperson: Robert N. Varney

JA-1 Variational Principle for Association/Dissociation in Dense Gases,* M. R. FLANNERY, School of Physics, GA Tech -- A new Variational Principle[1] is presented for the rate $R^A(t)$ of evolution towards equilibrium of a non-equilibrium distribution of (A-B) pairs, either associated or dissociated, in a gas M. An expression for $R^A(t)$ is developed in terms of the probabilities P_i^A for association of pairs with internal energy E_i. With simple variational analytical functions for P_i^A, application of the Variational Principle yields minima which are in exact agreement with detailed numerical results of the more time-consuming Quasi-Steady-State Method[1] which, in principle involves the solution of an integral equation for P_i^A and provides the minimum to $R^A(t)$. The new expression for R^A is also very valuable when approximate P_i^A, as those given by the diffusion treatment, are adopted. Results will be illustrated.

*Research supported by U.S.AFOSR under Grant AFOSR-84-0233.

1. M. R. Flannery, Phys. Rev. A. (submitted)

JA-2 Electronic Structure and Reactivity of C_2^+ As Seen by Fourier Transform Mass Spectroscopy. A. O'Keefe and J.R. McDonald, Chemistry Division, Naval Research Laboratory, Washington, DC 20375-5000

When trapping ions under very low pressure conditions (10^{-8} Torr), slow radiative relaxation of long-lived metastable electronic states in molecular ions can become competitive with ion-molecule reactions rates. Under such conditions ion-molecule reactions can be used as a probe to measure the radiative lifetimes of metastable state ions. The C_2^+ ion is expected to have low lying doublet and quartet electronic states but experimental data are lacking. An analysis of several ion-molecule reactions involving C_2^+ suggests that this ion is often formed in a mixture of ground quartet and metastable doublet states which exhibit distinct chemistry. The metastable doublet state is shown to have a radiative lifetime in excess of 5 sec.

JA-3 Analysis of Quintet He_2^* Formation Through Collisions of Triplet Metastable Helium Atoms,‡ H. H. Michels, UTRC -- Associative ionization of metastable $^3S(1s2s)$ He* atoms is dependent on the location of the pertinent interaction potentials for He* + He* collisions and on the lifetimes for radiative decay to the continuum of $He_2^+ + e$. Previous studies of this system have suggested the possibility of forming a bound nonautoionizing $^5\Sigma_g^+$ state of He_2^* with a long radiative lifetime. A series of ab initio calculations of the He* + He* potential curves has been carried out in a large scale CI framework. We find that the ionic $^5\Sigma_g^+$, $^5\Sigma_u^+$, $^5\Pi_g$ and $^5\Pi_u$ states arising from $He^+(^2S) + He^-(^4P)$ dominate the character of the long-range interactions and, in particular, give rise to the shallow minimum previously reported[1] for the lowest $^5\Sigma_g^+$ state. An analysis of the coupling of these ionic states to the $He_2^+ + e$ continuum indicates that the radiative lifetimes of the quintet He_2^* states are all shorter than ~10 μsec.

‡ Work supported in part by AFOSR under Contract F49620-83-C-0094.

[1] B. J. Garrison, W. H. Miller and H. F. Schaefer III, JCP 59, 3193 (1973).

JA-4 Rotational Energy Transfer in the Electronically Excited $B^3\Pi_g$ State of N_2, D.H. KATAYAMA, AFGL, Hanscom AFB--A two laser, double resonance technique is used to determine propensity rules for collision induced rotational energy transfer by Ar atoms in the N_2 $B^3\Pi_g$ (v = 3) state. A pulsed, pump laser selectively populates a rotational level of the B (v = 3) state by tuning it to the appropriate transition in the $B^3\Pi_g - A^3\Sigma_u^+$ (3,0) band. Collisional transitions to other rotational levels of the B (v = 3) manifold are determined by scanning the probe laser through the $C^3\Pi_u - B^3\Pi_g$ (0,3) band. A propensity for e - e and f - f collisional transfer are observed for the $^3\Pi_0$ component but not for $^3\Pi_1$ or $^3\Pi_2$. This is in agreement with the work of Alexander and Pouilly[1]. There does not appear to be any J specificity in the transfer between spin components.

[1] M. H. Alexander and B. Pouilly, J. Chem. Phys. 79, 1545 (1983).

JA-5 Long-Lived States in Nitrogen Afterglows, L.G.PIPER and G.E.CALEDONIA, Physical Sciences Inc., Andover, MA--In our studies of the afterglows of microwave discharge excited nitrogen, we have consistently noted persistent radiation from the First Positive and Lyman-Birge-Hopfield bands of N_2. These radiations are observed well downstream of the discharge and cannot result from direct microwave excitation of the radiating species. Furthermore the observed radiative intensities and spectral content are such to preclude the importance of nitrogen atom recombination as the source. A review of potential energy sources and mechanisms has led us to suggest that highly-vibrationally-excited ground state nitrogen provides the production source for these electronic states. We will review our data and provide suggested kinetic mechanisms and model predictions to demonstrate the potential coupling between the vibrational and electronic manifolds of nitrogen.

JA-6 Velocity Dependent Total Scattering Cross Section for $Ar(^3P_{2,0})$ on N_2. K.A. Hardy and J.W. Sheldon, Florida International University--The velocity dependent total scattering cross section has been measured for $Ar(^3P_{2,0})+N_2$ by the attenuation of a time of flight analyzed $Ar(^3P_{2,0})$ beam passing through a collision cell containing N_2 at 300°K. The cross sections rise monatonically with decreasing relative velocity of collision from approximately 250 $Å^2$ at 1.5 km/s to 500 $Å^2$ at 0.6 km/s. The data are fitted to elastic scattering cross sections numerically computed for a spherically symmetric potential with parameters adjusted for a best fit. The diffusion coefficient for $Ar(^3P_{2,0})$ in N_2 is determined from these parameters.

JA-7 Positive Ion Mobilities and Reactions in NH_3 Gas. Z. A. Talib and M. Saporoschenko, Southern Illinois University in Carbondale--Drift velocity measurements have been made as a function of E/p_o for the ions NH_4^+, $NH_4(NH_3)^+$, $NH_4(NH_3)_2^+$, and $NH_4(NH_3)_3^+$ in NH_3 gas at room temperature using a pulsed ion-transit-time method. The reduced zero-field mobility obtained by extrapolation for the most abundant ion $NH_4(NH_3)_3^+$ is 1.05 $cm^2/V\text{-}sec$. The reduced mobilities of the present work are compared with previous measurements.[1,2] The measured rate constants for reaction of the ions NH_4^+, $NH_4(NH_3)^+$ $NH_4(NH_3)_2^+$, and $NH_4(NH_3)_3^+$ are 4.8×10^{-28} cm^6/sec, 2.1×10^{-28} cm^6/sec, and 2.3×10^{-30} cm^6/sec, respectively, at E/p_o between 27 and 87.

1. C.W. Polley, Jr. et al, J. Am. Chem. Soc. 52, 1749 (1980).

2. F.D. Lange, Int. J. of Mass Spectrometry and Ion Physics, 37, 341 (1981).

SESSION JB

13:30, Thursday, October 17, 1985

IONIZATION AND ELECTRON HEATING

Chairperson: G.N. Hays
Sandia Nat'l Labs

JB-1 Microwave Conductivity Measurements of Electron-Beam-Ionized Air Afterglows, M.N. Spencer, J.S. Dickinson and D.J. Eckstrom, S.R.I. International--We have utilized microwave measurement techniques to determine conductivities in afterglow plasmas created by electron beam ionization by a 600 keV, 5000 A Febetron; the 1.0 MeV, 6500 A accelerator at McDonnell-Douglas Research Laboratories (Medea); and the 25 MeV, 300 A machine at Los Alamos National Laboratories (Phermex). In these experiments, the principal gases studied were synthetic air (79% nitrogen, 21% oxygen) and laboratory air containing varying amounts of water vapor. Other gases studied include pure nitrogen, helium and neon. We made measurements at various pressures from 1 torr to 1 atmosphere. We determined that the water vapor pressure had a significant effect in increasing the rate at which the conductivity decayed. In spite of the variety of experimental conditions employed, our results show a surprising degree of consistency in the decay rates measured as a function of pressure. However, these rates are slower than predicted by kinetic modeling using known electron attachment rates.

JB-2 *Electron Heating in Microwave-Afterglow Plasmas**, B. M. Penetrante** and J. N. Bardsley, *U. of Pittsburgh*--Numerical solutions of the Boltzmann equation are obtained for conditions typical of plasmas used in microwave-afterglow studies of the electron temperature (T_e) dependence of the dissociative recombination of electrons with molecular ions. It has been observed that (a) even for a few mTorr molecular gas in 10-20 Torr buffer gas, significant absorption of microwave energy can be accomplished through electron-molecule inelastic collisions, and (b) electron-electron energy exchange is significant but not sufficient in maxwellianizing the electron energy distribution. Thus, T_e depends not only on E/ω (electric field/frequency) but also on the partial pressure of the molecular gas and the electron density n_e. This complicates the analysis of the afterglow experiments since ambipolar diffusion frequency measurements sometimes cannot be used to establish the T_e scale. Furthermore, for a typical n_e decay of from 10^9 to $10^8 cm^{-3}$, it is sometimes not possible to assign a single T_e value to a certain E/ω.

* Work supported by the Office of Naval Research.

** Present address: Polytechnic Institute of New York

JB-3 Laser Heating of Low Temperature Plasmas with Application to Energy Conversion. N. W. JALUFKA, NASA, Langley Research Center - A short pulse (.45 J, 80 nsec FWHM) TEA CO_2 laser has been used to heat a low temperature (T_e < 1 eV), dense (ne ~ 10^{15} to 10^{16} cm^{-3}) hydrogen plasma. The plasma was produced in an electromagnetic shock tube without a reflector so that the flow was not stagnated. The laser pulse was absorbed in the contact front behind the incident shock wave. Absorption of the laser radiation is due to inverse Bremsstrahlung which preferentially heats the free electrons. Absorption of up to 65 percent of the laser beam was observed giving a measured increase in electron temperature of up to .25 T_e. The heated plasma flowed through a simple MHD generator with a 5.3 kiloGauss magnetic field allowing electrical energy to be extracted from the plasma. Conversion efficiencies in excess of 40 percent (electrical energy extracted/laser energy deposited) were measured.

JB-4 Statistical Mechanics of Rydberg Atoms.*
D. L. Huestis, SRI International--In moderately ionized dense hot plasmas the populations of the higher atomic excited states are strongly affected by collisions with electrons and the buffer gas. We have begun by supposing that the mean electron energy can be related to an effective temperature of the Rydberg levels. In an excimer laser, with an electron density of 10^{14} cm^{-3} and mean energy of 1 eV, the usual Debye radius "cut-off" fails to restrain the population at high principle quantum number, leading to divergence of the partition function. We have constructed a micro-canonical partition function based on box-normalization of JWKB coulomb wavefunctions, which, in agreement with previous investigators[1], shows three kinds of terms: bound electrons (Z independent of V), free electrons (Z proportional to V), and a third kind of electrons (Z proportional to fractional powers of V). We will discuss the implications of this partition function for calculation of the equilibrium fractional ionization and the populations in individual excited levels.

* Supported by the Office of Naval Research

1. V. S. Vorob'ev and V. S. Yungman, Teplofizika Vysokikh Temperatur, 17, 897 (1979).

JB-5 Two-Temperature Analog to the Saha Equation, P.A. VICHARELLI* and A.V. PHELPS, JILA, U. of Colo. & NBS. --The question of steady-state populations of atomic energy levels in a two-temperature plasma is considered. An analog to the Saha equation is derived on the basis of the kinetic method of Richley and Tuma[1] for the case where the balance between ionization and its inverse may occur through collisions with both electrons and heavy particles. The result depends not only on the two temperatures involved, but also on the relative concentration of electrons and neutral atoms , and the relative efficiency with which these particles produce ionization. If only electrons are responsible for the ionization and recombination, our equation reduces to the regular Saha equation, while for the case where the neutral atoms dominate, it correctly approaches the limit given by Collins.[2] The modified equation may also be used to define an effective temperature for the highly excited states. Results for a helium discharge are presented.

*Present address: GTE Labs, Inc., Waltham, MA.

1. E. Richley & D.T. Tuma,J. Appl. Phys. 53,8537(1982).
2. C.B. Collins, Phys. Rev. 158,94(1967).

JB-6 Collisional-Radiative Recombination and Net Ionization in Mercury Vapor, J.M. ANDERSON, General Electric Corporate Research and Development -- Collisional-Radiative recombination and net ionization in mercury vapor was computed using excited states of mercury through n=22 (0.013 eV from an assumed I.P. = 10.4 eV). Electron density was considered in the range 10^9 to 10^{15}/cc, mercury neutral density 10^{13}, 10^{14}, 10^{15}/cc, and electron temperature (Maxwellian dist. always assumed) 2,000 to 14,000°K. Collisional-radiative recombination (optically thin) was found to vary as $\alpha \cong 5 \times 10^{-27}$ Ne $(kT_e)^{-4.5}$ cm^3/sec. Net ionization was up to 10x greater than that found in models which use only the four lowest excited states. Associative ionization played only a very small role. Higher state densities closely approached thermal equilibrium with the free electrons for all cases except highest neutral mercury densities, lowest electron densities, and highest electron temperatures.

JB-7 The Role of Neutral-Neutral Inelastic Collisions in a Low-temperature Plasma, J.A. KUNC, U. of Southern California--The contribution of inelastic atom-atom collisions to the production of electrons and excited atoms in a two-temperature (with electron temperature T_e, atomic temperature T_a and atomic density N_a), steady-state atomic hydrogen plasma is investigated. The results are valid for an arbitrary plasmas which have a large amount of atomic hydrogen, so that e-H and H-H inelastic collisions and interaction of H atoms with radiation dominate production of electrons and excited hydrogen atoms. Densities of electrons and excited atoms are calculated for low-temperature plasma conditions, with T_e, $T_a \leq 8000°K$ and $10^{14} cm^{-3} \leq N_a \leq 10^{20} cm^{-3}$, and with varying degree of reabsorption of plasma radiation. The results show that atom-atom inelastic collisions are of great importance in low-temperature plasmas and this fact must be taken into account in plasma diagnostics.

SESSION KA

15:30, Thursday, October 17, 1985

GAS LASERS

Chairperson: H.T. Powell
Lawrence Livermore Nat'l Lab

KA-1 High-Pressure, Pulsed Radial Glow Discharges for CO_2 Lasers, * C. M. YOUNG, B. R. BECKES, T. J. BEEZHOLD, J. W. BENZE, J. M. ELIZONDO, W. M. MOENY, and J. G. SMALL, Tetra Corporation--Tetra Corporation has conducted experimental investigations of high pressure self-sustained radial glow discharges for pumping a CO_2 laser. This is the first time high pressure self-sustained glow discharges have been successfully run in a cylindrical geometry, with current in the radial direction, to our knowledge. Proof-of-concept was demonstrated by extraction of 1.2J from 1/10 of the 2.4 liter discharge volume (at 600 torr). Pulse lengths were on the order of 6 μs FWHM. Energy was provided to the laser discharge by a spark gap switched, DC charged, 2 Ω PFN. Typical charging voltages were around 30 kV with a discharge glow voltage to 15 kV. Pre-ionization preceded the main discharge pulse by 3-4 μs. Trimethylamine was added to the laser mix to enhance pre-ionization.

*Work supported by the U. S. Naval Sea Systems Command.

KA-2 CW Recombination Lasers in Electron Beam Generated Plasmas,* J. J. ROCCA, B. WERNSMAN and H. L. MANCINI†, Elec. Eng. Dept., Colo. State Univ.--Negative glow plasmas having an electron energy distribution in which energetic beam electrons and supercooled secondary electrons coexist under steady-state conditions are shown to be an attractive medium for excitation of recombination lasers. A pulsed electron beam (1-5A, 2-5 Kv) was used to excite a He-Cd mixture. Laser action was obtained in the CdI 1.[illegible], 1.40 and 1.64 μm lines of CdI following three body electron-ion recombination. CW laser oscillation was also obtained in the 1.43 μm recombination transition of CdI and in the 5337A and 5378A transitions of CdII in the afterglow of a hollow cathode discharge. The conditions required for CW oscillation are discussed. Advantages of electron beam excitation over previously used low temperature arcs[1] are: stable output, prolonged continuous wave operation and the possibility of producing shorter wavelengths using ion transitions.

*Work supported by the National Science Foundation and NSF-CONICET International Program.

†CITEFA-CONICET.

[1]Silfvast, Wood & Macklin, Appl. Phys. Lett. 347, 1983.

KA-3 High Efficiency KrF* Laser Using Electron Beam Sustained Discharge Pumping Of Kr/F2 Laser Mixtures.* E.T. SALESKY, and SID SINGER Los Alamos National Laboratory -- A computer model based on the work of Hunter and Johnson[1] is used to study discharge pumping and stability of the KrF* laser. We find that non-self-sustained discharges have sufficient stability and scalabilty to be of interest in ICF applications. Discharge pumping of mixtures containing only Kr and F2 is shown to give KrF* formation efficiencies of greater than 42% for pump rates of 150-200 kw/cm3 and pulse durations of 300 nsec. External ionization by a modest 1-2 A/cm2 electron gun is shown to be adequate to maintain a stable discharge until F2 burnup occurs. The stability is shown to be different during lasing and non-lasing conditions since photoionization perturbs the electron density. A design for a 1.5 kilojoule device with 20% intrinsic and 16% overall electrical efficiency will be presented. A brief discussion of the work of Jacob and Mangano[2] in comparison with our results will also be presented.

*Work supported by Los Alamos National Laboratory, DOE Contract No. W-7405-ENG-36.

1. A. Hunter and T. Johnson J of Appl. Phys., 51, 2406 (1980).
2. J. Jacob and J. Mangano Appl Phys Lett., --28--, 724 (1976).

KA-4 Temperature Dependence Measurements of Kr_2F^* Fluorescence in KrF* Laser Mixtures,* W.D. KIMURA, Spectra Technology, Inc., and E.T. SALESKY, Los Alamos National Laboratory -- This paper describes temperature dependence measurements of Kr_2F^* formation for gas mixtures of 89.7%Ar/10%Kr/0.27%F_2 and 99.6%Kr/0.4%F_2 in an electron-beam pumped KrF* laser. Measurements indicate that for the Kr/F_2 mixture, the Kr_2F^* peak fluorescence has an inverse square-root temperature dependence. This dependence is the same during lasing and non-lasing conditions. Using this temperature dependence, our computer model agrees well with the fluorescence data. This dependence is much weaker than that predicted by Shui[1], and may indicate that a strong temperature dependence of KrF* three body quenching may not apply when Kr is the third body.

*Work supported by Los Alamos National Laboratory, DOE Contract No. W-7405-ENG-36.

1. V.H. Shui, Appl. Phys. Lett., 34, 203 (1979).

KA-5 Analyses of XeF Ground State Kinetics. T.T. Yang, J.A. Blauer, and C.E. Turner, Jr., Rocketdyne Division, Rockwell International--We have characterized the dissociation kinetics of the ground electronic state of XeF in terms of a simple cascade model. The functional form of the collisional transition probabilities was assumed to be given adequately by Surprisal theory. Molecular dissociation was assumed to occur from the continuum, the rate for which was obtained from transition state theory.

A comparison of the model with bulk dissociation data allowed evaluation of the single disposable parameter. The collision probabilities for V-T exchange derived from the results are substantially smaller than those reported by Fulghum et al. This has considerable impact upon the expected performance characteristics of the XeF (B-X) laser due to the resulting increase in ground state number density.

KA-6 Solar Pumped Lasing of n-C_4F_9I and i-C_3F_7I, R. DE YOUNG, NASA Langley Research Center--Solar pumped photodissociation lasing has been achieved at 1.3 μm in both n-C_4F_9I and i-C_3F_7I using CW xenon arc solar simulators. For static gas pressures of from 1 to 16 torr, lasing lasts for 950 to 125 msec. Peak energy of 70 mj and average power of 500 mwatt occurred at 6 torr. Output energy was slightly lower for C_4F_9I due to its higher quenching of I*, but lasing threshold was lower than i-C_3F_7I. A gain of 2 percent per cm and loss of 0.9 percent per cm were found by varying the output mirror reflectivity. Laser threshold input intensity was found to be 17 w/cm^2 making these systems easily pumped by concentrated sunlight. The experimental results are compared to a kinetic model which outlines the dominant reaction pathways.

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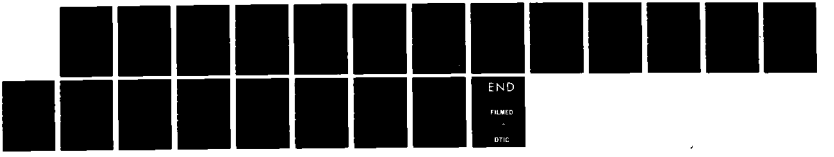

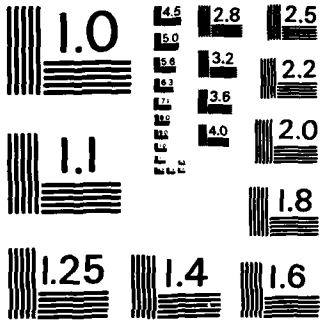

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

SESSION KB

15:30, Thursday, October 17, 1985

SHEATHS AND DISTRIBUTION FUNCTIONS

Chairperson: S.A. Self
Stanford U.

KB-1 The Energy Distribution of Electrons in a Propagating Glow Discharge Beam,* B-X. SHI, Z. YU, K. JAYARAM and G. J. COLLINS, COLORADO STATE UNIVERSITY- We compare theoretical and experimental data on the creation and propagation of a glow discharge produced electron beam. The beam mode of operation occurs within a limited range of gas pressure and voltage applied to the cathode of the plasma gun [1]. The computer model calculates the electron energy distribution in the 1-2KV electron beam both as it is created and as it propagates through the dark space. The calculated energy distribution of electrons within the cathode dark space includes the contributions from collisions of slow electrons (1-100 eV) with gas atoms near cathode surface. Calculations and measurements of the beam intensity versus energy are in good enough agreement to extract the origin of different electron-atom collision process that broaden the measured energy distribution of the propagating electron beam.

*Work supported by Office of Naval Research and National Science Foundation.

[1] Z. Yu, J. J. Rocca and G. J. Collins, J. Appl. Phys. 54, 131 (1983).

KB-2 Three-Term Approximation of the Boltzmann Equation for N_2 at High E/N, M.F. Fréchette and J.P. Novak, IREQ, Varennes, Québec, Canada--Previous model[1] calculations simulating steady-state Townsend discharge have been extended to include a third term in the spherical-harmonic expansion of the electron distribution function. The formulation which is essentially that of Makabe and Mori,[2] renders the problem of anisotropic diffusion tractable and allows to test the convergence of the isotropic distribution function (f_o). Both longitudinal (D_L) and transverse (D_T) diffusion coefficients are calculated while in the two-term approximation, an isotropic diffusion coefficient (D_o) was determined. At E/N = 606 Td, D_T/μ is found to be smaller than D_o/μ_o ($\sim$4%) while the ratio D_L/D_T is approximatively 25%. The anisotropy f_1 is shifted towards low energy compared with that of the two-term approximation and as a consequence, produces a slight increase of the ionization coefficient ($\sim$1%).

[1] J.P. Novak and M.F. Fréchette, J. Appl. Phys. 55, 107 (1984).

[2] T. Makabe and T. Mori, J. Phys. D: Appl. Phys. 13, 387 (1980).

KB-3 Primary Electron Energy Loss in the Negative Glow of a Hg/Ar Low Pressure Arc, JOHN M. ANDERSON, General Electric R&D Center, Schenectady, NY--Electrons emitted into the negative glow of a low pressure arc in mercury/argon mixtures were followed by a Monte Carlo procedure to find their energy loss in elastic and inelastic processes. Residual electron density was taken at 10^{12}, 10^{13}, and 10^{14}cc and cathode fall in the range 8 to 20 volts. Few mercury ions are formed under any conditions, and mercury is excited only at low residual densities. Argon is very strongly excited when the cathode fall is about 14 volts and for densities up to 10^{13}/cc. For 10^{14}/cc, most of the energy goes to the residual electrons.

KB-4 Steady-State Characteristics of a Hydrogen Thyratron Discharge* B.M. Penetrante, E.E. Kunhardt and E. Levi, Polytechnic Institute of New York--A numerical analysis of a hydrogen thyratron discharge has been made in order to predict (a) the composition of neutral and charged particles, and (b) the kinetic properties of the electrons, during the conducting state, given only a minimum set of free parameters. The discharge is assumed to have two compartments: (1) the cathode space; and (2) the grid space, with fetzing[1] having taken place. In the cathode space, a set of particle balance equations is solved self-consistently with the Boltzmann equation. In the grid space, the electron energy distribution is treated in two parts: the high energy group corresponding to those accelerated across the double sheath, and the low energy group of thermalized electrons. Contributions due to excited atomic states, diffusion and radiation trapping are included. The sensitivity of the plasma chemistry and the stability of the double sheath are studied under different pulse lengths and tube geometries.

* Work supported by the Office of Naval Research and the Air Force Weapons Lab.

[1] H. Fetz, Ann. Phys., *37*, 1-40 (1940).

KB-5 Theory of Runaway Electrons in a Weakly Ionized Plasma - K.-U. RIEMANN, Ruhr-Universität Bochum, FRG.
The stationary, homogeneous electron Boltzmann equation is considered for the case of high electric fields. To account for the runaway effect the velocity space is devided into two energy regions. For low energies the Boltzmann equation is solved by the usual two term spherical harmonic expansion. This expansion breaks down at the runaway threshold. Above this threshold we construct an approximation, which is valid near the field axis and which can describe the formation of a runaway beam. We calculate the rate of runaway electrons and discuss its effect on the ionization coefficient.

KB-6 Asymptotically Correct Collisional Presheaths,* G. L. Main, School of Mechanical Engineering, Georgia Institute of Technology -- Existing work on collisional presheaths either assumes very restrictive collision terms or attempts numerical calculations in specialized cases.[1,2,3] This paper develops a solution method for collisional presheaths based on an asymptotically correct potential distribution. The developed method produces closed form asymptotic solutions for simple collision terms (single point dependent in velocity space) and shows promise for extension to more general collision terms. Also, the method shows promise for actual convergence over the presheath region rather than only asymptotic correctness at the plasma-presheath interface. Simple collision term results are shown.

*Work supported by AFOSR

1. Chodura, R., Phys. Fluids 25, 1628 (1982)
2. Emmert, G. A. et al., Phys. Fluids 23, 803 (1980)
3. Riemann, K. V. Phys. Fluids 24, 2163 (1981).

KB-7 Plasma Profiles in Low Pressure DC Discharges,*
J.P. HAUCK, E.H. HUFFMAN and R.J. BLAIR, Calif. State University Fullerton -- We have measured Langmuir probe ion current and floating potentials in small bore (3.3mm dia.) inert gas plasmas. From these we have inferred the plasma density and potential profiles. We find that the plasma profiles are in good agreement with the predictions of the ambipolar diffusion model in the interior, i.e., density α Jo Bessel Function, and potential α the log of Jo. The plasma density does not extrapolate to zero at the wall. Measurements were performed under conditions of pressure 2 - 10 Torr, current 0.5 - 2mA and HeNe gas mixtures. Wall densities and potentials were only weakly dependent on these parameters and were approximately 8% of the central density and -6V with respect to the central potnetial.

*Work supported in part by Rockwell International and Northrop Electronics Division Independent R&D funding.

SESSION LA

08:30, Friday, October 18, 1985

R-F DISCHARGES

Chairperson: L.C. Pitchford
GTE Labs, Inc

LA-1 NEGATIVE ION KINETICS IN RADIO FREQUENCY GLOW DISCHARGES, Carl E. Gaebe and Richard A. Gottscho, AT&T Bell Laboratories, Murray Hill, NJ 07974. We report *in situ* measurements of local electric fields and opto-galvanic signals resulting from photodetachment of negative ions in BCl_3 and Cl_2 rf discharges. The opto-galvanic signal is used as a measure of the instantaneous anion density during the rf cycle. Because of competition between dissociative attachment when the applied voltage is small and collisional detachment when the voltage is large, the anion density is strongly modulated on the time scale of a single rf cycle at frequencies below 750 kHz. Large anion densities in the sheath region reduce the plasma's ability to rectify the applied voltage and the plasma potential is observed to lie below the anode potential. Above 750 kHz, the applied voltage crosses zero too rapidly for electrons to attach in sufficient numbers. Thus, the anion density is not strongly modulated above this frequency and is negligibly small in the sheath regions.

LA-2 Axial Plasma Density and Electron Temperature Profiles of Ring Type Capacitance Coupling Flowing RF Glow Discharge Argon Plasma, J.S. CHANG, H. ARISHIMA, S. MATSUMURA McMaster Univ. Canada, S. TEII Musashi Inst. Tech., Japan --- Experimental studies of axial plasma density, and electron temperature profiles of ring type capacitance coupling radio-freguency (13.7 MH_Z) flowing argon plasma have been conducted. Plasma parameters are measured by a series of electrostatic probes inside cylindrical discharge tubes. The experimental results are obtained for the gas flow velocity from 0 to 1 m/s gas pressure from 0.7 to 10 torr, and RF power from 5 to 30 W. The results show that : (1) The effect of gas flow velocity on the axial plasma density profiles agrees qulitatively well with the recent flowing positive column theory of Miller and Chang (1985), except near RF electrodes plasma depletions and electron temperature enhancements has been observed ; (2) The effect of RF power on the axial electron temperature and plasma density profiles is observed to be small ; however, the absolute magnetude of plasma density increases nonlinearly with increasing RF power.

LA-3 A Model for the Bulk Plasma in an RF Chlorine Discharge. G.L. ROGOFF, J.M. KRAMER, and R.B. PIEJAK, GTE Laboratories Inc.--A relatively simple model has been constructed to describe the electrical characteristics of the central bulk plasma in a 13.56 MHz parallel-plate discharge in chlorine at pressures of about 1 Torr. The plasma is modeled as volume-controlled with the electron balance dominated by one-step electron-impact ionization and attachment and with the electron energy distribution function in equilibrium with the local instantaneous electric field. Relationships between the ionization frequency, the attachment frequency, the electron drift velocity, and the electric field are obtained by solving the Boltzmann equation for mixtures of Cl_2 and Cl which result from Cl_2 dissociation. From a measured current waveform and Cl_2/Cl ratio the model generates the local field waveform, the time-varying electron density, and the power density in the central portion of the plasma. The calculated time-averaged power input per unit discharge length compares well with values determined experimentally by varying the gap spacing. The effective dc electric field for high-frequency discharges characterizes the power input per unit length quite well, but it does not correctly characterize the electron balance.

LA-4 Motion of Intensity Layers in an RF Parallel Plate Discharge at 13.56 MHz, P. Bletzinger and C.A. DeJoseph, Jr, Air Force Wright Aeronautical Laboratories--At 13.56 MHz ions can no longer follow the electric field in a discharge, while the electron plasma frequency is still about 2 orders of magnitude larger. Using a photomultiplier, suitable detection and mechanically scanning the discharge along its axis, we have measured the propagation characteristics of the intensity peaks corresponding to excitation waves in several gases at pressures from 80 to 300 mTorr. Starting at the electrode which at that instant is negative, the peaks increase their velocity until, at a point where the average electron density reaches its maximum, the velocity becomes infinite and can even reverse direction. The amplitudes correspond to the average intensity distributions previously reported for different pressures and gases. This behavior can be interpreted as a time and spatially varying electrostatic wave where the phase velocity is a function of distance or, more accurately, of collision frequency and electron density along the discharge axis.

LA-5 Particle Distributions and Laser-Particle Photophysics in an RF Discharge of Silane in Argon, K.G. SPEARS, T.J. ROBINSON, and R.M. ROTH*, NORTHWESTERN U.-- A capacitively coupled, rf glow discharge of silane in argon was studied with laser probes. We characterized spatial distributions of particles with laser light scattering at several wavelengths. The spatial scans had a resolution of 0.25 mm and they revealed unusual particle distributions with changes in silane mole fraction and gas flow rates. We also explored particle photophysics and demonstrated that particle interactions with ultraviolet pulsed lasers (251.4 and 266 nm) can form silicon atoms in ground and excited states. These atoms increase in concentration with increasing ultraviolet laser energy. Laser excitation with 354 nm or 532 nm did not form atoms. However, pulsed excitation at 354 nm increased the steady state light scattering signal over long times, which is consistent with enhanced particle growth from laser-particle interactions.

*Present address: AMOCO Corporation, Corporate Research, P.O. Box 400, Naperville, IL 60566.

SESSION LB

08:30, Friday, October 18, 1985

ARCS AND SWITCHING

Chairperson: J. Anderson
General Electric R&D Ctr

LB-1 MECHANISM OF ARC COMMUTATION IN SWITCHING DEVICES. K.-P. Nachtigall, Ruhr-U. Bochum, FRG. The time an arc needs for leaving the contacts and jumping on rail electrodes determines the lifetime of circuit breakers. Contact life could be increased by shortening the commutation time leading to a reduction of contact erosion. To investigate the mechanism, we developed an arrangement for commutating an arc of variable length and current up to 500 DC. The arc jumped electrodes of different materials with different surfaces. Investigations were made in air at atmospheric pressure. Voltage and current characteristics were measured simultaneously using high-speed photography and show the arc motion and cathode foot initiation. We are now able to make statements about the physical mechanism of arc commutation which are of relevance for contact life increase in switching devices.

LB-2 SPECTROSCOPIC INVESTIGATIONS OF A LOW CURRENT ARC IN FLUORINE. H.-L. Hausmann, Ruhr U. Bochum, FRG. Fluorine is the main constituent of SF_6. It is used in rare-gas-halogen excimer lasers. It is of interest to know properties of fluorine as the integral cross-section Q_{eF} of electrons and fluorine atoms. To ascertain this cross-section, we developed a special arc tube in which we are able to operate a pure fluorine arc. With spectroscopic studies of this arc, we get the radial distribution of the temperature $T_e(r)$ and the density $N_e(r)$ of the electrons as well as the temperature $T_g(r)$ of the fluorine atoms. The temperature of the electrons T_e can be determined by measuring the decrease of the F$^-$-continuum to shorter wavelengths. By measuring the increase of the radiation emission coefficient of red fluorine lines by switching off the arc, we determine the temperature difference $T_e - T_g$. Any increase is caused by a non-equilibrium state. Knowing T_e, we ascertain T_g. With these parameters and the measured value of the electrical conductivity we are able to ascertain Q_{eF}.

LB-3 New Transition Probability Scale for Argon*
A. SEDGHINASAB, T.L. EDDY, Georgia Institute of Technology--Using Multithermal Equilibrium (MTE) analysis[1], new transition probability scale for argon has been established by mapping the various kinetic and excitation temperatures of a constricted arc over a pressure range of 1 to 5 atm. LTE criterion is given based on the obtained T-P map. The spectroscopic measurements have been corrected for absorption and line wings. Fowler-Milne off-axis peaking method has been used. The electron density is deduced from both the continuum measurements as well as the H_β line broadening technique. Results indicate a significant deviation of atmospheric arcs from LTE. The new scale is compared to the values given by Wiese (NBS)[2], and Wende[3].

*Work supported by NSF Grant No. CPE-8311325.
[1]T.L. Eddy et al., IEEE Trans Plasma Sci.,1, 31, 1973.
[2]W.L. Wiese et al., NSRDS-NBS-22, 1969.
[3]B. Wende, Z. Physik, 213, 341, 1968

LB-4 Temperature Measurements of a Dynamic Turbulent Nitrogen Arc in High Speed Flow*, U. Sen and D.M. Benenson, State University of New York at Buffalo--Spatial and temporal distributions of average temperature and its fluctuations have been obtained for a dynamic nitrogen arc. The single flow interrupter contained a converging-diverging nozzle with 10mm throat diameter and electrode spacing of 110mm. Operating conditions included: stagnation pressure = 14 bar; peak current - 1.4kA; and dI/dt at current zero ≅ - 19A/μs (calculated). Nitrogen continuum radiation centered at 432.0nm was employed to determine arc temperatures. Data were obtained at axial positions 3mm and 20mm downstream of the throat. Centerline temperature near the throat was ~ 13800K at 440A and decayed to ~ 11600K at 140A, while the fluctuations increased from 6% to 9%. Centerline temperature downstream of the throat decayed from ~ 12200K (at 800A) to ~ 10700K (at 480A), with fluctuations of 6% at 800A and 9% at 480A. Calculations of centerline temperatures were within 8% of experimental results near the throat and within 18% at the downstream station.

*Research supported by National Science Foundation grants CPE 8007187 and CPE 8313963.

LB-5 Properties of Arcs in the Boundary Layer of an MHD Generator or Accelerator,* R. J. Rosa, Montana State University--A mathematical model for an arc across a region of steep gradients of velocity, turbulence intensity, temperature, and ambient plasma electrical conductivity, has been developed and found to correlate well with available experimental data. The model predicts the current, voltage, and dimensions of each arc and the number of arcs per electrode as a function of boundary layer thickness, surface roughness, electrode and free stream temperature, Hall parameter, and other ambient conditions. The effect of boundary layer thickness and shape is strong, and is of particular interest for extrapolating from small scale experiment to large scale device.

*Work supported by the National Science Foundation.

LB-6 Unipolar Arcs*. F. SCHWIRZKE, Naval Postgrad. School. --Many unipolar micro-arcs will be ignited, even without any external voltage applied, when a plasma of sufficiently high electron temperature interacts with a surface. Unipolar arcing is caused by local changes of the sheath potential associated with electron pressure gradients within the plasma. A micron-size spot on the surface serves as cathode and a small surrounding area as anode. The available plasma energy concentrates towards the cathode spot, and this leads to cratering of the surface. The jet of material ejected from the crater increases the plasma pressure above the cathode. The resulting 3-dimensional electric field configuration drives the arc current and also facilitates the electron return current to the surface by lowering the sheath potential in a circular area surrounding the cathode spot. The existence of unipolar arcing has been verified by using laser produced plasmas[1]. Unipolar arcing provides an explosive emission of plasma and in this way it can serve also as an efficient initiating mechanism for bipolar breakdown processes between electrodes.

*Supported by Naval Postgrad. School Found. Res. Program

[1]F. Schwirzke, "Laser Interaction and Related Plasma Phenomena," H. Hora and G.H. Miley, eds., Plenum Press, N.Y., Vol. 6, 335-352 (1984).

SESSION M

10:30, Friday, October 18, 1985

INVITED LECTURES

Chairperson: D.L. Huestis
SRI Internat'l

M

M-1 FREE ELECTRON LASERS. J. Slater,
Spectra Technology Inc

M-2 SPACECRAFT GLOWS. T.G. Slanger
SRI Internat'l

INDEX OF AUTHORS

38th Annual Gaseous Electronics Conference

October 15-18, 1985 Naval Postgraduate School, Monterey

Monday, October 14

18:00-22:00		Reception and Registration	Herrmann Hall (La Novia Room)

Tuesday, October 15

07:30		Registration opens	Spanagel Hall (Room 101A)
08:15-08:25		Welcome	King Hall
08:25-09:40	A	Electron-Molecule Collisions: Excitation (R.S. Freund)	King Hall
10:10-12:30	B	XUV Lasers (W.L. Morgan)	King Hall
14:00-17:00	CA	Posters Collisions (F. Schwirzke)	Herrmann Hall
	CB	" Discharges "	(Barbara McNitt
	CC	" Photonics "	Ballroom)

Wednesday, October 16

08:00-09:30	DA	Electron-Molecule Collisions: Attachment (M. Dillon)	King Hall
	DB	High-Pressure Arc Lamps (J. Maya)	Ingersoll Hall (Room 122)
10:00-11:55	EA	Ion-Molecule Reactions (R. Johnsen)	King Hall
	EB	DC-Glows (A. K. Bhattacharya)	Ingersoll Hall (Room 122)
13:00-14:20	FA	Electron-Molecule Collisions: Total Scattering and Excitation (R. St.John)	King Hall
	FB	Plasma Chemistry (R.A. Gottscho)	Ingersoll Hall (Room 122)
14:45-17:15	G	Symposium on Ion-Molecule Reactions (E.E. Ferguson)	King Hall

Thursday, October 17

08:00-09:20	H	Breakdown (J. Proud)	King Hall
09:50-11:50	I	Loeb Commemorative Session (L. Fisher)	King Hall
13:30-15:00	JA	Heavy Particle Collisions (R. Varney)	King Hall
	JB	Ionization and Electron Heating (G.N. Hays)	Ingersoll Hall (Room 122)
15:30-17:00	KA	Gas Lasers (H.T. Powell)	King Hall
	KB	Sheaths and Distribution Functions (S.A. Self)	Ingersoll Hall (Room 122)
20:00		Banquet	Sheraton Hotel

Friday, October 18

08:30-10:00	LA	R-F Discharges (L.C. Pitchford)	King Hall
	LB	Arcs and Switching (J. Anderson)	Ingersoll Hall (Room 122)
10:30-12:00	M	Invited Lectures (D.L. Huestis)	King Hall

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